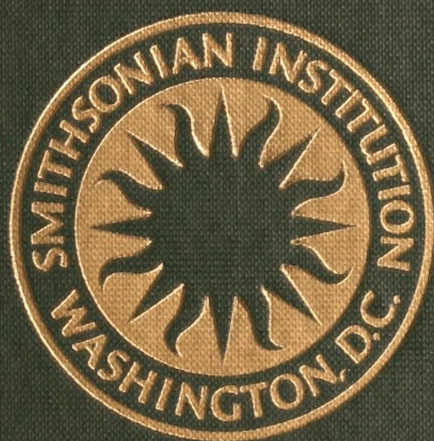




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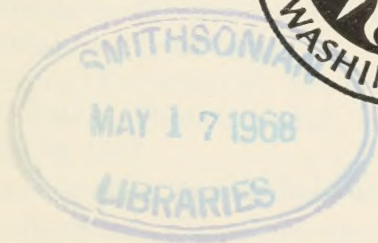
PROCEEDINGS

OF THE

UNITED STATES NATIONAL MUSEUM

VOLUME 123

NUMBERS 3601-3623



SMITHSONIAN INSTITUTION PRESS
WASHINGTON : 1967

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FRANK A. TAYLOR

Director, United States National Museum

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3601

Neotropical Species of Genus *Triplax* Herbst And Review of Genus *Haematochiton* Gorham (Coleoptera: Erotylidae)¹

By David H. Johnson ²

Neotropical Species of Genus *Triplax* Herbst

Although largely Holarctic in distribution, the genus *Triplax* Herbst ranges into tropical regions to some extent, especially the New World tropics. Some species having been erroneously referred to the genus and most species being inadequately described and poorly known, this paper is an attempt to clarify the confusion surrounding the Neotropical forms.

The first Neotropical species, *Triplax cruentipennis*, was described by Lacordaire in his monograph of 1842. In 1864 Philippi described *T. valdiviana*. Gorham's work in the "Biologia Centrali-Americana" in 1888 added four new species, *T. championi*, *T. högei*, *T. mesomelas*, and *T. rediviva*. Guérin (1952) described *T. bicolor* and *T. azureipennis*. In 1957, Delkeskamp described *T. maderi* from Brazil, and Boyle (1954, 1956, 1962) has described four species from Arizona whose ranges are either known or thought to extend into Mexico.

¹ Modified from a master's thesis submitted to Pennsylvania State University, 1966.

² Department of Entomology, Oklahoma State University, Stillwater.

In this study *T. cruentipennis* Lacordaire and *T. maderi* Delkeskamp have been removed from *Triplax* as now described and have been referred to *Haematochiton* Gorham. *Triplax valdiviana* Philippi has been declared incertae sedis because of the inconspicuous small pronotal angle pores, the lack of a brush on the maxillary palpal terminal segments, and the extremely elongate appearance (length to width ratio: 2.5 to 1). *Triplax azureipennis* has been declared incertae sedis, while *T. bicolor* is declared *Triplax(?) bicolor* Guérin. The present author has been unable to locate the types of these two forms.

The exact relation of the following genera, listed as Neotropical Triplacinae by Blackwelder (1945), to the Neotropical species of *Triplax* is not known: *Psclaphacus* Percheron; *Megischyrus* Crotch, *Ischyrus* Lacordaire, *Oocyaneus* Hope, *Callischyrus* Crotch, *Mycomystes* Gorham, *Mycophthorus* Lacordaire, *Pseudolybas* Gorham, *Lybas* Lacordaire, *Lybanodes* Gorham, *Mycolybas* Crotch, and *Neoxestus* Crotch. It is felt, however, that the closest related genera to the Neotropical species of *Triplax* are *Paratritoma* Gorham, *Tritoma* Fabricius, *Haematochiton* Gorham, and *Mycotretus* Lacordaire. Species of *Haematochiton* Gorham are recognized easily by their weakly widened, semicircular maxillary palpal terminal segments, by their inconspicuous, small pronotal angle pores, and by a body shape similar to *Triplax*.

Neotropical *Triplax* species are separated easily from *Paratritoma* by the pronotal angle pores. In *Paratritoma* the pores are small and inconspicuous, while in *Triplax* they are large and distinctly umbilicate. In other characters, such as the length to width ratio of the body, shape of the pronotum, development of the postmandibular lobes, and width of the terminal segments of the maxillary palpi with distinct apical brush, few significant differences have been found. Thus, at present, *Paratritoma* is considered the most closely related of the Neotropical genera to *Triplax*.

The one Neotropical *Tritoma* specimen examined, that of *T. dorsalis* Gorham, can scarcely be confused with *Triplax*. Its broadly oval body, long prosternal lines, and maxillary palpal terminal segments without apical brush are all non-*Triplax* characters.

The taxonomic results of this study are that three specific names have been placed in new synonymy and three new species are described. Four species previously placed in *Triplax* are referred to *Haematochiton* Gorham or are declared incertae sedis. One species is, at present, of uncertain taxonomic position, while another species is moved from *Paratritoma* Gorham to *Triplax*. Twelve species are listed as Neotropical members of the genus *Triplax*.

METHODS AND TERMINOLOGY.—Male genitalia were prepared by relaxing the beetle for about an hour in warm water to which detergent had been added. After this relaxing, the abdomen was separated from the thorax and elytra, and the unsclerotized mass of tissue was removed from the sternites. The abdominal sternum was then placed, along with the rest of the beetle, on a new point and pin. The genitalia and associated soft organs were then soaked overnight in 10 percent KOH in "Plant Industry" syracuse dishes. After no more than 24 hours the genitalia were separated from associated residue, rinsed, and manipulated so that the internal sac was forcibly everted to show pigmentation and sclerotization of its inner surface. The anterior end of the internal sac was examined after being stained with merthiolate.

"Neotropical" as used in this work refers to all of the New World south of the United States, i.e., all of Mexico, Central America, the Antilles, and South America.

The terminology of external morphology is essentially that of Torre-Bueno (1962), while male genitalia terminology is essentially that of Sharp and Muir (1912).

The use of two words to indicate color refers to a blending of color hues. Thus, yellowish brown implies more brown than yellow. In all other cases involving color, the terminology is that of Torre-Bueno (1962).

ACKNOWLEDGMENTS.—The author was fortunate in having had the opportunity to examine 249 Triplacinae specimens from 13 museums and personal collections. To the following museums and personal collectors the author would like to extend his thanks for the loan of these specimens: American Museum of Natural History (AMNH); British Museum (Natural History), London (BM); California Academy of Sciences (CAS); Chicago Natural History Museum (CNHM); Department of Agriculture (Canada), Entomology Research Institute (DA); D. R. Whitehead personal collection, University of Alberta, Alberta, Canada (DRW); M. Alvarenga personal collection, Rio de Janeiro, Brazil (MA); Museum of Comparative Zoology, Harvard (MCZ); Museum National d'Histoire Naturelle, Paris, France (MN); University of Arizona (UA); University of California, Berkeley (UCB); United States National Museum (USNM); W. W. Boyle, Pennsylvania State University (WWB).

The author owes special thanks to M. Alvarenga, Rio de Janeiro, Brazil, for his loan of specimens; to W. W. Boyle, Pennsylvania State University, under whose guidance work on *Triplax* was undertaken; to A. Descarpentries of the Museum National d'Histoire Naturelle, Paris, for lending the type of *T. cruentipennis* Lacordaire; and to

H. S. Dybas, Chicago Natural History Museum, who lent a great number of Neotropical *Triplacinae*.

SYSTEMATIC TREATMENT.—Neotropical *Triplax* species display a wide range of coloration and moderate intraspecific variation in this coloration. Coloration includes black, ferrugineous, piceous, fulvus, yellowish brown, yellow, orange red, and red. Their general shape ranges from elongate-elliptical to relatively oval; the body length to width ratio ranges from about 1.6:1 to about 1.95:1. Specimens studied ranged in length from 2.34 to 5.12 mm and in width from 1.28 to 2.81 mm.

The head is elongate-oval, fitting tightly in the prothorax, and is visible from above. The eyes are finely faceted. The antennae are 11-segmented, generally more than one-half the width of the pronotal base; the club is relatively lax, its length 2 or more times its width. Antennal segmental coloration varies within some species. The terminal segments of the maxillary palpi are moderately to extremely widened, their width ranging from about 2.75 to 4 or 5 times their length; the maxillary palpus has a distinct brush present along the truncate apex. The terminal segments of the labial palpi are short-setigerous, each armed with a brush along its truncate apex. The mentum varies from small and obscurely pentagonal to larger and more distinctly pentagonal, with considerable intraspecific variation. The postmandibular lobes range in development from moderate to strong; in some species they are of diagnostic value, in others they are not.

The pronotum is margined laterally and basally, but it is immarginate medioapically between the eyes. Its shape ranges from subquadrate to subtrapezoidal. The pronotal angle pores are distinctly umbilicate, of moderate to large size.

The elytral striae are in some species strongly impressed, in others they are not. The elytra are basally margined or immarginate.

The prosternal lines are generally absent but when rarely present they are short, straight, not exceeding extreme anterior edges of coxae. The prosternum, with various degrees of punctuation among the species, is subtrapezoidal in shape. Prosternal, pronotal epipleural, mesosternal, metepisternal, and metepimeral sclerites, among others, are distinct. Metasternal coxal lines are generally absent but occasionally they are short, vestigial.

The abdomen is composed of five sternites, the first being the widest. This basal sternite has a narrow intercoxal process (not nearly so broad as in the closely related genus *Tritoma* Fabricius). The abdominal coxal lines are usually present.

The anterior and middle coxae are globular; those of the hindlegs are transverse. In comparison to the closely related genus *Tritoma*,

the coxae are narrowly separated and the tibiae are weakly widened apically. The hind trochanters are right triangular. The femora are somewhat swollen. The tarsi are 5-segmented with segment 4 strongly reduced; segment 3 has all four sides straight or nearly so.

One part of the male genitalia, the anterior end of the internal sac, has been shown by Boyle (1956) to demonstrate specific diagnostic relationships. The present study supports this.

Little is known concerning the life habits of this genus. In eastern North America favorite fungus hosts of *Triplax* species are species of *Pleurotus*, a soft bracket fungus; and in Arizona, *T. thompsoni* has been taken in large numbers on *Polyporus arcularius* on oak.

Genus *Triplax* Herbst

Triplax Herbst, 1793, p. 146, pl. 49 (figs. 13, n). [Type-species: *Silpha russica* Linné, 1758, p. 360, by subsequent designation by Curtis, 1838 (1824-1840), vol. 15, p. 706.]

The following key to the Neotropical members of the genus *Triplax* includes three species—*T. thompsoni*, *T. marcescens*, and *T. californica*—the Mexican specimens of which are not definitely known. It is believed, however, that their ranges extend into Mexico, and for this reason they are included.

Key to Neotropical Species of *Triplax*

- 1. Antennae black beyond segment 2, the stem clothed with moderately dense, coarse, black setae; antennal club narrow, segment 10 no more than twice as wide as segment 7; head above entirely reddish yellow; Arizona, Mexico? **marcescens** Boyle
- Antennae not black or not entirely black, at least part of the antennae in addition to segments 1 and 2 lighter 2
- 2. Elytra distinctly margined basally 3
- Elytra immarginate basally, at most with a vestige of a margin laterally near the humeral callus. 10
- 3. Pronotum bearing a median apical and a smaller piceous spot near the middle of each side, the latter often weak, sometimes obsolete; anterior and lateral edges of postmandibular lobes sharply rounded, not posteriorly divergent; southwestern U.S., Mexico **mesosternalis** Schaeffer
- Pronotum without spots 4
- 4. Elytra yellow to red 5
- Elytra never entirely yellow to red, some portion or all piceous to black . . 6
- 5. Pronotum piceous to black, not yellow to red; Texas, Mexico . **errans** Boyle
- Pronotum yellow to red; Central America **alvarengai**, new species
- 6. No part of pronotum black 7
- Some part of pronotum black 9
- 7. Abdomen usually testaceous; terminal segments of maxillary palpi moderately widened, their width less than 3 times length; eastern North America to Panama **flavicollis** Lacordaire
- Abdomen not testaceous; terminal segments of maxillary palpi strongly widened, their width more than 3 times length 8

8. Mesothorax and metathorax not entirely black; cephalic and pronotal punctures not exceptionally coarse; antennal club not abruptly 3-segmented; Arizona, Mexico. **wehrlei** Boyle
 Mesothorax and metathorax entirely black; cephalic and pronotal punctures exceptionally coarse; antennal club abruptly 3-segmented; Arizona, Mexico? **thompsoni** Boyle
9. Elytral striae strongly impressed; maxillary palpal terminal segments not exceptionally wide, width about 3.5 times length; lateral edges of post-mandibular lobes straight (fig. 7); Mexico. **sola**, new species
 Elytral striae not strongly impressed; maxillary palpal terminal segments exceptionally wide, width about 4.7 times length; lateral edges of post-mandibular lobes not straight (fig. 4); Brazil. . . **latipalpus**, new species
10. Elytra not particolored 11
 Elytra particolored 12
11. Antennae entirely yellow or testaceous; pronotal angle pores of normal size; Guatemala **rediviva** Gorham
 Antennae not entirely yellow or testaceous; pronotal angle pores extremely large; western North America, Mexico? **californica** LeConte
12. Pronotum particolored; 60 percent of elytral length behind base not entirely yellow; Costa Rica, Central America? **divisa** (Gorham)

***Triplax alvarengai*, new species**

FIGURE 1

Diagnostic description: Color variable, ranging from fulvus, with or without elytral apical region darker, to nitidous red; underside testaceous to brownish; number of yellow antennal segments variable; body moderately nitidous. Body shape essentially elliptical, anterior and posterior ends about equally parabolically rounded, ratio of length to width 1.6 to 1; pronotum subtrapezoidal, basal width about three-fifths greater than apical width; elytra widest at about 35 percent of length behind elytral base. Antennal length about equal to distance to pronotal base, club 4-segmented, segment 10 about 3.5 times width of segment 7. Apex of epistomofrontal region of head faintly concave in very shallow arc or V, epistomal apex immarginate. Postmandibular lobes moderate in size, lateral edges somewhat rounded; terminal segments of maxillary palpi strongly widened, width about 3.5 times length; mentum rather small, size and shape somewhat variable. Pronotal punctures not deeply impressed, somewhat more closely spaced and deeply impressed laterally; cephalic punctures much more closely spaced and coarser; elytral striae moderately impressed.

Variation: Color is somewhat variable. Specimens examined from the Canal Zone displayed a brown to black area in the apical elytral 20 to 40 per cent. An examination of the anterior end of the internal sac (fig. 1), however, has shown all of these specimens to be con-

specific. The size range of the 22 specimens examined is: length 2.81–4.27 mm; width 1.69–2.39 mm.

Male genitalia: Illustrated in figure 1.

Holotype: Male, labeled "Ciruelas, Costa Rica, IX-22-30; collected by A. Alfaro" (property of CNHM). Its measurements are: length 3.71 mm; width 2.14 mm.

Type-locality: Ciruelas, Costa Rica.

Paratypes: MEXICO: Veracruz, Coyame (Whitehead; WWB), 4; Veracruz, Buen Pais (Bechtel and Schinger; CNHM), 1; Veracruz,

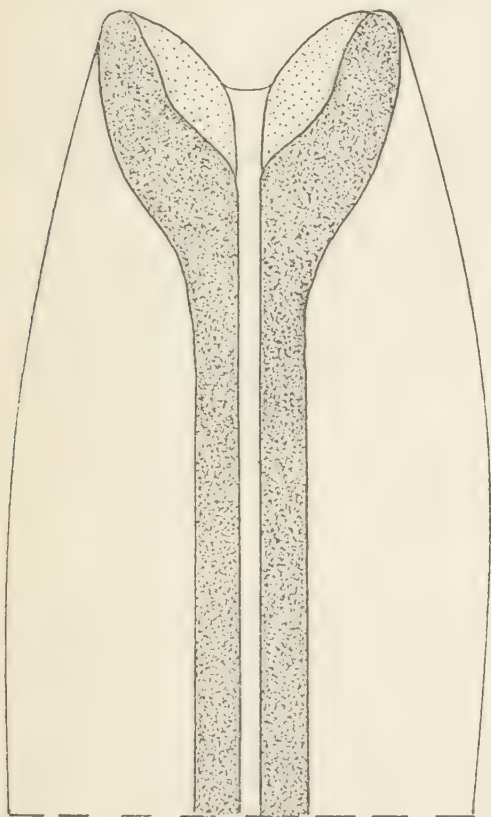


FIGURE 1.—*Triplax albarengai*, new species: anterior end of internal sac, anterodorsal view.

Cerro Gordo (SeEVERS; CNHM), 1. COSTA RICA: Same data as type (CNHM), 1. PANAMA: Canal Zone, Barro Colorado (Darlington; AMNH), 1; Canal Zone, Barro Colorado Island (lot 47-4230; USNM), 1; Canal Zone, Fort Clayton (Frick; CAS), 1; Paraiso (Schwarz; USNM), 1. EL SALVADOR: La Libertad (Bechyne, MA), 5; La Libertad (Bechyne; WWB), 5.

Distribution: From Panama to Mexico.

Triplax divisa (Gorham), new combination

FIGURE 2

Paratritoma divisa Gorham, 1888, p. 72, pl. 4 (fig. 11).

Diagnostic description: Head, medial portion of pronotum, anterior one-sixth of elytra, and posterior one-half of elytra piceous; remainder dark yellow above. Underside entirely piceous except for legs, maxillary and labial palpi, pronotal epipleura anteriorly, and posterior one-third of abdomen. Scape and pedicel yellowish; other segments, except for last three which are piceous, yellowish brown. Body moderately nitidous. Shape somewhat elliptical, length about 1.78 times width, body widest at about three-tenths of elytral length behind base, length to width ratio very close to that of *T. latipalpus*, about 1.75 to 1. Last antennal segment bulbous and large, segment 10 about 3 times width segment 8. Postmandibular lobes long, posteriorly slightly divergent, edges somewhat rounded (fig. 2). Terminal segments of maxillary palpi strongly widened, ratio of width to length about 3.6 to 1, distinct brush along entire apex present (fig. 2). Mentum similar to *T. latipalpus*. Head punctures relatively deep, separated by less than 1 to greater than 4 times their diameter, prominent setae in punctures; pronotal punctures fine.

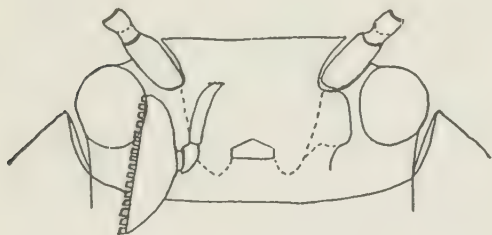


FIGURE 2.—*Triplax divisa* (Gorham), new combination: underside of head.

Discussion: The adult is figured in full color by Gorham (1888, pl. 4: fig. 11). In this study two specimens were examined. Labeling is as follows: "Costa Rica, F. Nevermann, 24-VI-'29, property of U.S.N.M." (USNM, a female). "Ciruelas, Costa Rica, collected by A. Alfaro, IX-22-'30" (CNHM, a female). Alvarenga (1965) has stated that *Paratritoma divisa* Gorham is the type-species of *Paratritoma* Gorham. This in effect synonymizes *Triplax* and *Paratritoma*. Gorham made three original watercolor drawings of the three "varieties" he considered to be *P. divisa*. The first two are red and black in color, the third yellowish and piceous. I have examined a series of *Paratritoma* species that I agree to be indeed *Paratritoma*. Figure 11, however, as illustrated by Gorham (1888), and the descrip-

tion thereof provide strong evidence that figure 11 is indeed that of a form that should be considered *Triplax*.

Male genitalia: Male not known.

Type: Not seen.

Distribution: Costa Rica.

Triplax errans Boyle

FIGURE 3

Triplax errans Boyle, 1956, p. 110.

Diagnostic description: Head above and gular region below black, prothorax and antennal clubs black; elytra and scutellum orange red to brilliant strongly nitidous red (except in teneralis); antennae grading from brownish yellow to black; genae, mouthparts, pterothorax, abdomen, and legs brownish yellow; body strongly nitidous. Overall shape short and broad, sides of body subparallel from middle of pronotum to middle of elytra, length to width ratio 1.8 to 1; body widest at about one-third the elytral length behind base; pronotum

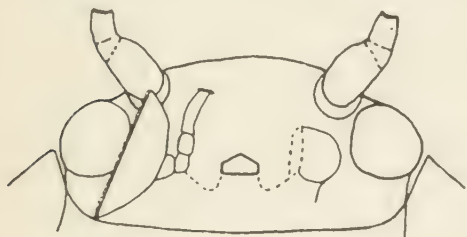


FIGURE 3.—*Triplax errans* Boyle:
underside of head.

widest just in front of base, sides evenly arcuate and strongly convergent apically. Postmandibular lobes, terminal segments of maxillary palpi, and mentum are shown in figure 3. Antennae two-thirds as long as width of pronotal base, the club 5-segmented and gradually widening over segments 7 to 9. Pronotal punctures of moderate size, somewhat larger and denser laterally, each bearing a minute seta that feebly exceeds the puncture; cephalic punctures denser apically, each bearing a protruding seta; elytral intervals minutely punctuate.

Variation: The 35 specimens examined ranged in length from 2.85 to 4.34 mm and in width from 1.57 to 2.51 mm. Boyle (1956) states that the measurements of the type are: length 4.14 mm; width 2.30 mm.

Male genitalia: Boyle (1956, p. 166, fig. 99) illustrates the anterior end of the internal sac.

Type: Male; labeled "Brownsville, Texas, VI-30-38; holotype, *Triplax errans* Boyle" (R. I. Sailer; collection University of Kansas).

Type-locality: Brownsville, Cameron Co., Tex.

Distribution: Other than the holotype from Brownsville, Tex., this species is known at present only from San Luis Potosí, Mexico. The material examined included 35 specimens from the following localities in San Luis Potosí: Tamazunchale, Huichihuayan, and Pajal.

Triplax flavicollis Lacordaire

Triplax flavicollis Lacordaire, 1842, p. 218.

Triplax confinis LeConte, 1854, p. 162.

Triplax championi Gorham, 1888, p. 78. [New synonymy.]

Triplax högei Gorham, 1888, p. 78. [New synonymy.]

Triplax mesomelas Gorham, 1888, p. 79. [New synonymy.]

Diagnostic description: Color variable; elytra ranging from ferrugineous to black; the following yellow to testaceous: head, pronotum, prothorax, and mesothorax; metathoracic coloration variable, sometimes metepisterna and metepimera are black, sometimes entire metathorax is black; abdomen testaceous to piceous; antennal coloration variable, club ranging from reddish yellow to piceous, stem grading from reddish yellow to piceous; body moderately nitidous. Body shape somewhat elliptical, anterior and posterior ends about equally parabolically rounded. Postmandibular lobes short, their lateral edges often somewhat rounded and divergent posteriorly; terminal segments of maxillary palpi moderately widened (see Boyle, 1956, p. 164, fig. 76), their width approaching 3 times their length, a distinct brush present along entire apex; mentum small; antennal club gradually 4-segmented. Pronotal punctures of moderate size, not deep; cephalic punctures much larger and denser; elytral striae impressed, small punctures present in elytral intervals; elytra distinctly margined basally.

Variation: The observed size variation of the 108 Neotropical specimens examined is: length 2.60–5.12 mm; width 1.44–2.81 mm.

Discussion: The three "species" that Gorham listed as distinct have not been found to be so. A "separation" of the specimens by comparison of the postmandibular lobes (and coloration of the metathorax according to Gorham's descriptions) of *T. championi*, *T. högei*, and *T. mesomelas* showed intergradation and cast doubt on the tenability of these three "species." A comparison of the anterior end of the internal sac of the "three forms" showed that they were conspecific.

Male genitalia: See Boyle (1956, p. 166, fig. 93).

Type: Not seen.

Type-locality: North America.

Distribution: North America east of the 100th meridian from Quebec to Florida and Texas, south into Mexico and Central America

to Panama. The material examined included 108 specimens from the following localities: MEXICO: Jalisco, Acatlán; Morelos, Ixtapan de la Sal; Cerro de Plumas; Guerrero, Acahuizotla; Nayarit, San Blas. GUATEMALA: Sacatepequez, Finca San Rafael, 7200 ft. EL SALVADOR: La Libertad; Fingalapaz. PANAMA: Canal Zone: Barro Colorado, and Paraiso; Bugaba.

Triplax latipalpus, new species

FIGURE 4

Diagnostic description: Head reddish brown; pronotum ferrugineous laterally, piceous medially; elytra and scutellum black; the following yellowish brown: underside of head, mouthparts, legs, prothorax, mesothorax, and posterior half of abdomen; anterior half of abdomen and elytral epipleura piceous; antennae yellowish brown except for piceous terminal four segments. Body strongly nitidous. Shape somewhat elliptical, length about 1.75 times width; body widest at about one-third elytral length behind base. Antennal segment 10 about 2.4 times width of segment 8. Postmandibular lobes distinctive, large in size, lateral edges somewhat rounded (fig. 4). Terminal

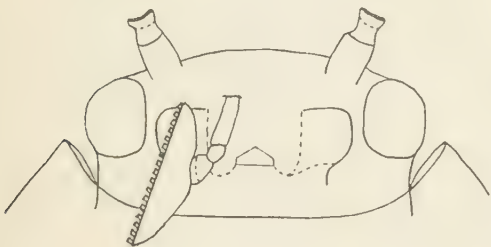


FIGURE 4.—*Triplax latipalpus*, new species: underside of head.

segment of maxillary palpus extremely widened with distinct brush, width about 4.7 times length (fig. 4). Head punctures with prominent setae; elytral interval punctures prominent, elytral striae not strongly impressed. Antennal setae sparse.

Male genitalia: Male not known.

Holotype: Female. Labeled "Brasilien, Nova Teutonia, 27°11'8'', 52°23'1'', 5-VI-1957 F. Plaumann" (WWB; placed in USNM). Its measurements are: length 4.04 mm; width 2.17 mm.

Type-locality: Nova Teutonia, Brazil.

Paratype: Female; labeled "Brasilien, Nova Teutonia, 27°11'8'', 52°23'1'', X-1957 F. Plaumann" (WWB; in personal collection of W. Wayne Boyle, Pennsylvania State University).

Distribution: The two specimens examined were collected in Brazil.

Triplax mesosternalis Schaeffer

Triplax mesosternalis Schaeffer, 1905, p. 145.

Triplax monostigma Casey, 1916, p. 165.

Triplax coloradana Casey, 1924, p. 179.

Diagnostic description: Piceous black color, the prothorax (except three black pronotal spots, one medio-apical and a smaller one on each side), head, mesosternum, mesepisterna, and appendages reddish yellow; mesepimera and hind coxae piceous; lateral piceous spots of pronotum only slightly smaller than median apical spot, placed far laterally, slightly anterior of middle, and about equidistant from apex and side of pronotum, median apical spot always present, lateral spots often weak, rarely not detectable; antenna beyond segments 1 and 2 darker than head; body moderately nitidous. Antennae relatively long, length equal to about nine-tenths of width of pronotal base, club 3-segmented. Postmandibular lobes short, lateral edges somewhat rounded and subparallel; terminal segments of maxillary palpi moderately widened, width slightly more than twice length (Boyle, 1956, fig. 78, p. 165). Pronotal punctures coarse, becoming larger and denser laterally where they are mostly separated by about the distance of their diameters or slightly less; cephalic punctures small and dense medially and apically, sparser and approximately as large as pronotal punctures laterobasally near eyes; elytral intervals bearing minute punctules more numerous than striae punctures and a weak meshwork of fine fissures; elytra moderately nitidous, distinctly margined basally.

Variation: Boyle (1956) states the variation of the 230 specimens he examined to be 3.31 to 5.11 mm in length and 1.52 to 2.35 mm in width. The measurements of the one specimen examined in this study are: length 3.77 mm; width 2.03 mm.

Male genitalia: The anterior end of the internal sac is illustrated by Boyle (1956, p. 166, fig. 94).

Type: Boyle (1956) chose a lectotype from a series of 5 cotypes at the USNM and labelled it "Lectotype, Boyle, 1952." The material examined in this study included one specimen from Chiapas, Mexico.

Triplax rediviva Gorham

FIGURES 5, 6

Triplax rediviva Gorham, 1888, p. 79, pl. 4 (fig. 19).

Diagnostic description: Elytra ferrugineous to piceous; scutellum testaceous to ferrugineous; head and pronotum testaceous; metathorax and abdomen ferrugineous; rest of underside, including legs, testaceous; antennae wholly testaceous; metacoxae usually ferrugineous. Body moderately nitidous. Body shape elongate-elliptical, anterior

and posterior ends about equally parabolically rounded, ratio of length to width about 1.95 to 1. Antennal club 4-segmented, setal vestiture moderate, width of segment 10 about 2.6 times that of segment 7. Apex of the epistomofrontal region of the head essentially straight. Lateral edges of postmandibular lobes posteriorly divergent (fig. 5), overall shape close to that of *T. californica*; terminal segments of

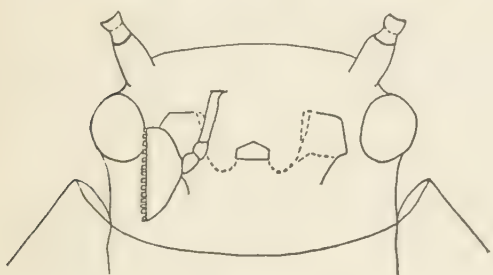


FIGURE 5.—*Triplax rediviva* Gorham: underside of head.

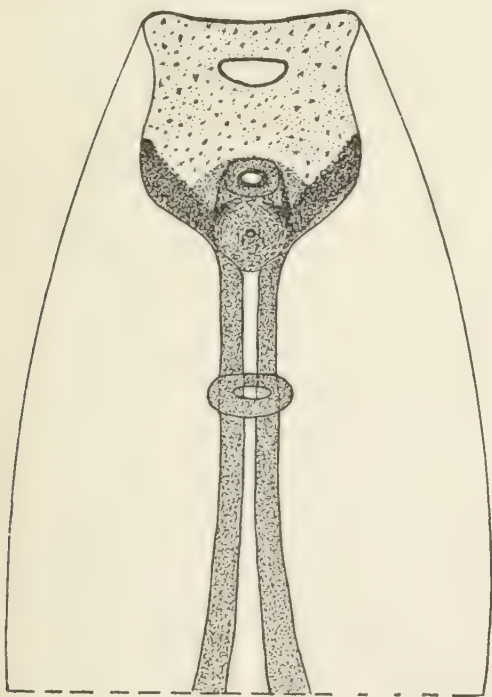


FIGURE 6.—*Triplax rediviva* Gorham: anterior end of internal sac, anterodorsal view.

maxillary palpi moderately widened, their width about 2.75 times their length (fig. 5); mentum small. Pronotal punctures coarse and deep; head punctures somewhat coarse, not evenly arranged; elytral striae impressed, elytral interval punctures present; prosternum covered with exceptionally large and deep punctures; pronotum covered with finer punctures; metasternum with large punctures laterally but not so sharply incised as on the prosternum, a single long seta projecting from each metasternal puncture.

Variation: The range in size of all specimens examined is: length 3.20–4.22 mm; width 1.57–2.14 mm.

Male genitalia: The anterior end of the internal sac is illustrated in figure 6.

Type: Not seen; collected by Champion; Gorham (1888, pl. 4: fig. 19) shows the type in color, but the name is misspelled "*redivivus*" on the plate.

Type-locality: Guatemala, Quiche Mountains, 8000 feet.

Distribution: Known only from Guatemala: the type-locality and Sacatepequez, Finca San Rafael, 7200 ft.

Triplax sola, new species

FIGURE 7

Diagnostic description: Entire dorsal surface black except for tawny basal three-fourths of elytra; antennae, mouthparts, and legs piceous, rest of the underside black. Body moderately nitidous. Body shape elongate-elliptical, ratio of length to width about 1.95 to 1; anterior and posterior ends about equally parabolically rounded,

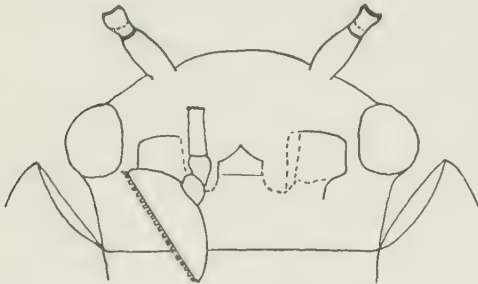


FIGURE 7.—*Triplax sola*, new species: underside of head.

widest point at about one-fifth of elytral length behind base; pronotum subtrapezoidal, basal width about seven-tenths greater than apical width. Antennae extending to pronotal base, segment 10 about twice width of segment 8. Apex of epistomofrontal region of head feebly concave. Postmandibular lobes with lateral edges straight (fig. 7); terminal segments of maxillary palpi strongly widened, width about 3.5 times length (fig. 7). Pronotal punctures laterally dense and large, medially somewhat finer, with setae that exceed rims; cephalic punctures dense; elytral striae strongly impressed, elytral intervals punctulate; elytra distinctly margined basally.

Discussion: The specific epithet *sola* refers to the single specimen examined in this work.

Male genitalia: Male not known.

Holotype: Female. Labeled "San Juan del Rio, 10 Mi. E., Quere Taro, Mexico, 30-VII-1954, J. G. Chillcott collector" (DA). Its measurements are: length 4.08 mm; width 2.12 mm.

Type-locality: San Juan del Rio, Quere Taro, Mexico.

Triplax wehrlei Boyle

Triplax wehrlei Boyle, 1954a, p. 260.

Diagnostic description: Ferruginous to reddish yellow in color, antennal clubs and elytra black, elytral epipleura reddish yellow, scutellum piceous; body weakly nitidous, feebly pubescent on head and pronotum above and on entire thorax below, abdomen with stronger pubescence. Postmandibular lobes short, lateral edges strongly rounded, subparallel (see Boyle, 1956, fig. 84, p. 165), terminal segments of maxillary palpi strongly widened, width more than 3 times length. Antennal length equal to about two-thirds width of pronotal base, club 4-segmented (or 5-segmented if one includes segment 7), gradually emergent. Epistomofrontal region of head with sides straight to feebly convex, apical angles of epistoma moderately rounded, apex more strongly concave in a shallow V than *T. flavicollis*. Pronotal punctures moderate size and density, separated by about the distance of their diameters; cephalic punctures similar in size but denser, each with a seta; elytral intervals with moderately large punctures (more than twice as numerous as striae punctures), and strong meshwork of fine fissures; elytra margined basally.

Variation: The 39 specimens examined ranged in size from 2.34 to 3.69 mm in length and 1.28 to 2.00 mm in width. The 3 specimens examined by Boyle (1956) from southern Arizona ranged in length from 4.14 to 4.55 mm and in width from 2.12 to 2.30 mm.

Discussion: The 39 specimens examined is the largest series, at present, known to have been studied. Heretofore, this form was known only from southern Arizona.

Male genitalia: The anterior end of the internal sac is illustrated in Boyle (1956, fig. 96, p. 166).

Type: Boyle (1956) states the following: "Male; labeled 'Patagonia, Ariz., VII-9-30; holotype, *Triplax wehrlei* Boyle' (J. O. Martin; collection C.A.S.)."

Type-locality: Patagonia, Santa Cruz Co., Ariz.

Distribution: The 39 specimens examined in this study were all taken at Morelos, Mexico. Thus, the present known range of this form is Arizona to Morelos, Mexico.

Review of Genus *Haematochiton* Gorham

The taxonomic history of this group began with Gorham's establishment of *Haematochiton* as a new genus in the Triplacinae in 1888 (1887-1899). He established *H. elateroides* Gorham, 1888, as the type-species. Blackwelder's Neotropical catalog lists one species as *Haematochiton*: *H. elateroides* Gorham, 1888. Boyle (1956) syn-

onymized the genus *Scaoether* Gorham, 1888, with *Haematochiton* Gorham, 1888. Boyle (1956) synonymized *H. biscalptum* Casey, 1916, with *H. elateroides* Gorham, 1888, and synonymized the following two forms under *H. carbonarius* (Gorham, 1888), new combination: *Scaoether carbonarius* Gorham, 1888 (1887-1899), and *Scaoether opacus* Schaeffer, 1915. Boyle (1956) created a key for the two species then recognized: *H. elateroides* Gorham, 1888, and *H. carbonarius* (Gorham). Alvarenga in 1965 stated that the type-species is *Haematochiton elateroides* Gorham, 1888.

In the present study four species are recognized in the Neotropical region and in the southwestern United States. *H. elateroides* Gorham and *H. carbonarius* (Gorham) are kept in *Haematochiton* while two forms heretofore described as *Triplax* are transferred to *Haematochiton*.

Distribution: The genus *Haematochiton* Gorham occurs only in the Western Hemisphere. Specimens have been taken in the southwestern United States, Mexico, and Brazil.

METHODS AND TERMINOLOGY.—Methods are the same as those used for *Triplax* (see p. 3).

"Neotropical" and other terminology are also the same as those used in *Triplax* (see p. 3).

ACKNOWLEDGMENTS.—For the genus *Haematochiton*, the author is indebted to the same collectors and institutions for the loan of material and Triplacinae specimens as for *Triplax* (see p. 3).

The author owes special thanks to Dr. W. Wayne Boyle, Pennsylvania State University, under whose guidance work on *Haematochiton* was undertaken.

SYSTEMATIC TREATMENT.—*Haematochiton* species display several colors, including dull carbonaceous black, nitidous black with blood red, and black with yellow. The general shape can best be described as elongate-elliptical with anterior and posterior ends of the body almost equally parabolically rounded, the anterior end somewhat more obtusely rounded, however. The ratios of the length to the width vary from 1.9 to 2.2:1. In lateral view the dorsal profile is somewhat flattened medially.

The head is visible from directly above. The eyes are finely faceted, small, but vaguely coarser than in *Triplax*. The ocular striae terminates at or behind the antennal insertions and the epistoma is consequently immarginate. The antennae is about equal to three-fifths to three-fourths of the pronotal basal width in length; its club is 4- to 5-segmented and is gradually emergent from the stem; segment 3 is subequal in length to segments 4 and 5 together. The maxillary palpi are semicircular and are less than twice as wide as long and are not armed with a distinct apical brush; the maxillary palpi are much

larger than the securiform terminal segments of the labial palpi; the labial palpi terminal segments are securiform, each bearing a single stronger seta laterally, and armed with a minute brush along the truncate apex. The lacinia is armed with two small incurved teeth at apex; and the postmandibular lobes are somewhat reduced to moderate in size.

The pronotum is subquadrate to subtrapezoidal in shape, while the sides are moderately arcuately convergent anteriorly; the apical width is subequal or equal to the median length. The pronotum is finely margined basally and laterally, immarginate apically between the eyes, and the pronotal angle pores are small and inconspicuous, not large and umbilicate. The elytra is distinctly basally margined.

The legs are distinctly tridentate at apex; the tibiae are not or very slightly dilated apically and are feebly arched; the coxae are moderately separated.

Abdominal pubescence is extremely faint to moderate. Pubescence is, however, not indicated as being of strong taxonomic importance.

The anterior end of the internal sac is distinctive.

The strongest differences between *Haematochiton* and *Mycotretus* are those of color and punctuation, the somewhat more obtusely rounded anterior end of the body in the former, and the absence in the former of the pronotal margin at apex between the eyes.

The most obvious differences between species of *Triplax* and those of *Haematochiton* are shown by the following characters of the latter: maxillary palpi terminal segments semicircular, not moderate to strongly widened with terminal brush; pronotal angle pores small and inconspicuous, not large and distinctly umbilicate.

Species of *Tritoma* Fabricius and *Paratritoma* Gorham hardly can be confused with *Haematochiton* Gorham. *Paratritoma* has moderate to strongly widened maxillary palpi terminal segments with distinct brush; *Haematochiton* does not. *Tritoma* is characterized by an oval to elongate-oval form in the Nearctics; *Tritoma dorsalis* Gorham from Panama is broadly oval; *Haematochiton* species on the other hand are elongate-elliptical.

Nothing is known of the life habits of *Haematochiton* species. The genus does not contain species of economic importance.

Genus *Haematochiton* Gorham

Haematochiton Gorham, 1888, p. 81. [Type-species: *H. elateroides* Gorham, 1888, p. 81, pl. 5 (fig. 4), by monotypy.]
Scaeothea Gorham, 1888, p. 82.

Key to Species of *Haematochiton* Gorham

- 1. Elytra orange red or blood red 2
- Elytra dull black or black 3

2. Prosternal lines connecting apicomediaally on prosternum; metasternal coxal lines long; Brazil **cruentipennis** (Lacordaire)
Prosternal lines not connecting apicomediaally on prosternum; metasternal coxal lines short or absent; southwestern United States, Mexico.
elateroides Gorham
3. Pronotum yellow with black spots; Brazil **maderi** (Delkeskamp)
Pronotum dull black, without spots; southwestern United States, Mexico.
carbonarius (Gorham)

Haematochiton cruentipennis (Lacordaire), new combination

FIGURE 8

Triplax cruentipennis Lacordaire, 1842, p. 205.

Diagnostic description; Head, pronotum, and scutellum black; elytra red with orange tinge, faint parallel lines of darker pigmentation on intervals; underside entirely black including legs and mouthparts. Overall shape elongate-elliptical, length to width ratio about 1.9 to 1. Antennae entirely reddish yellow except for blackish terminal 4 or 5 segments; antennal club strongly widened, ratio of width of segment 10 to that of 6 is 3.3 to 1; antennae extending to the base of the prothorax, setae of club dense. Maxillary palpi ratio width to length about 1.5 to 1 (fig. 8). Postmandibular lobes relatively small, strongly rounded posteriorly and anteriorly (fig. 8). Pronotum subtrapezoidal in shape, widest basally, sides moderately arcuately convergent anteriorly; the four pronotal angles are in equal focus

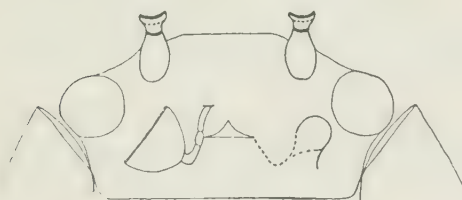


FIGURE 8.—*Haematochiton cruentipennis* (Lacordaire), new combination: underside of head.

when viewed from above. Pronotal angle pores small and inconspicuous. Pronotal punctures relatively small and shallow medially, suddenly becoming much larger on lateral thirds. Elytral intervals punctured. Prosternal coxal lines unusually large and prominent extending to prosternal apical region and connecting medioapically. Cephalic punctures relatively large and flat bottomed along base, becoming smaller and denser apically. Abdominal pubescence and punctuation moderate.

Variation: The observed size of the one specimen examined, the holotype, from the Museum National d'Histoire Naturelle, Paris, is: length 5.63 mm; width 2.98 mm.

Male genitalia: The unique type was not dissected.

Biology: Nothing is known of the biology of this form.

Type: Sex unknown, in Museum National d'Histoire Naturelle, Paris, labeled "*cruentipennis* Lacordaire, Type, 'Brasil'."

Type-locality: "Brasil."

Distribution: The only specimen known to the author is that of the unique type labeled "Brasil."

Haematochiton elateroides Gorham

Haematochiton elateroides Gorham, 1888, p. 81, pl. 5 (fig. 4.)

Haematochiton bisculptum Casey, 1916, p. 168.

Diagnostic description: Coloration of head and pronotum black, elytra blood red except at extreme apices. Overall shape is elongate-elliptical; two ends of the body are about equally parabolically rounded, length to width ratio about 2.2 to 1. Maxillary palpi terminal segments moderately widened without distinct brush. Pronotum subtrapezoidal, moderately convergent anteriorly, median length about one-eighth shorter than the apical width, the four pronotal angles are in view when viewed from directly above. Pronotal punctures relatively small and shallow medially, suddenly much larger and distinctly flat bottomed on lateral thirds. Elytra blood red except at apices, relatively nitidous. Cephalic punctures relatively large and flat bottomed along base, becoming smaller and denser apically. Abdominal pubescence and punctuation weak. Abdominal and metasternal coxal lines absent; if occasionally present, they are short basal traces. Specimens of *H. elateroides* Gorham from the Chiricahua Mountains were compared with the unique type of *H. cruentipennis* (Lacordaire). The most obvious differences between the two species are shown by the following characteristics of the former: elytral intervals impunctulate, not punctured; metasternal coxal lines short to absent, not long and prominent; prosternal coxal lines short, not long and connecting medioapically on the prosternum; abdominal punctuation weak, not moderate; abdominal pubescence extremely faint, not moderate; body length to width ratio 1.9 to 1, not 2 to 1.

Male genitalia: The median lobe (see Boyle, 1956, fig. 135) is narrowly membranous along the broad opening of the median orifice. The aedeagus is quite similar to that of *Mycotretus nigromaniscatus* Boyle in gross characteristics. The distinctive anterior end of the internal sac is illustrated in Boyle (1956, fig. 136).

Published illustrations: The adult is figured in color by Gorham (1887-1899, pl. 5: fig. 4).

Type: Not seen.

Type-locality: "Ciudad in Durango, 8100 feet, Mexico."

Distribution: This species has been collected in the southwestern United States and in Mexico. The following localities have been

reported: MEXICO: Durango: "Ciudad in Durango, 8100 feet." UNITED STATES: Arizona: Cochise Co.: Chiricahua Mountains, July 20, 1950, July 1936, and June 24; Pine Creek, Chiricahua Mountains, June 24, 1897; Rustler Park, 8000-9000 feet, Chiricahua Mountains, July 20, 1950. Maricopa Co.: Phoenix.

Haematochiton maderi (Delkeskamp), new combination

FIGURES 9, 10

Triplax maderi Delkeskamp, 1957, p. 114.

Diagnostic description: Coloration of head and elytra black. Overall shape elongate-elliptical; two ends of body about equally parabolically rounded; length 2.1 times the width. Eyes small, finely faceted, but coarser than in *Triplax*. Ocular striae terminating at antennal insertions, the epistoma immarginate. Antennae extending to procoxae, club 4-segmented, about twice as long as wide, densely



FIGURE 9.—*Haematochiton maderi* (Delkeskamp), new combination: underside of head.

clothed with setae of moderate coarseness; segment 3 of stem about equal in length to segments 4 and 5 together. Maxillary palpi terminal segment width to length ratio about 1:1 (fig. 9), semicircular, without brush. Mentum moderately large. Terminal labial palpi segments more cylindrical than in *Triplax*. Postmandibular lobes of moderate development (fig. 9). Pronotum subtrapezoidal, apical width about one-fifth less than the basal width, sides subparallel for about one-half distance nearest base. Pronotum yellow with six black spots, two of these are in one-fifth of the pronotum behind apex, the others are evenly transversely spaced medially. Pronotum margined basally, and laterally, immarginate apically between the eyes. Pronotal angle pores moderately small and relatively shallow. Elytra margined basally. Scutellum subcordate. Body below similar to *Triplax* with the following exceptions: the prosternal lines along the coxal inner edges are strong, straight, and subparallel; metasternal coxal lines absent; abdominal coxal lines short. Coloration: elytra and head black; pronotum yellow with six black spots, two of these at one-fifth of the pronotum behind apex, the other four evenly transversely spaced medially; the following ferruginous: antennae, underside of head (medially), legs, mesothorax, metathorax, and abdomen

(except posteriorly); the following testaceous: prothorax, palpi, tarsi, and, indeterminately, the abdominal posterior one-third.

Discussion: *H. maderi* can not be considered as *Triplax* because of the species' following critical characters: terminal segments maxillary palpi weakly widened without distinct apical brush; pronotal angle pores small, shallow.

Male genitalia: The anterior end of the internal sac is distinctive (fig. 10), showing a similarity to the anterior end of the internal sac of *H. carbonarius* Gorham as drawn by Boyle (1956, p. 138).

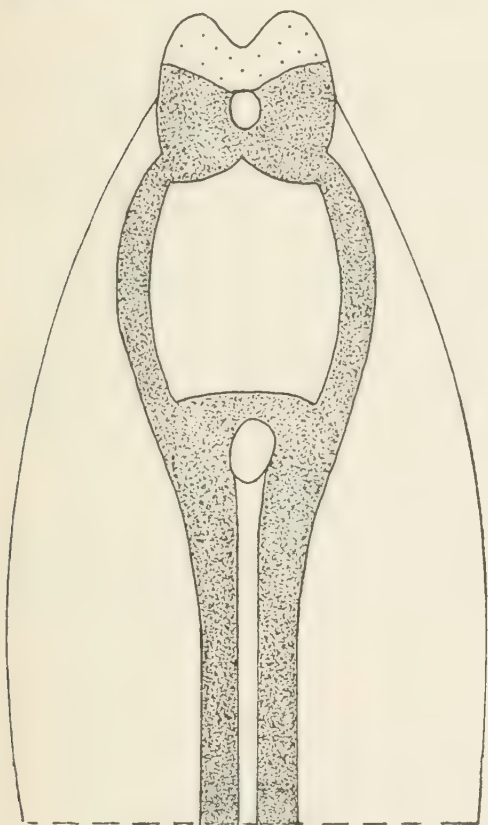


FIGURE 10. — *Haematochiton maderi* (Delkeskamp), new combination: anterior end of internal sac, anterodorsal view.

Biology: Nothing is known of the biology of this form.

Type-locality: Brazil?

Distribution: In this study specimens have been taken from the following locality: BRAZIL: Nova Teutonia, 27°11'8'', 52°23'1''.

Haematochiton carbonarius (Gorham)

Scaeothe carbonarius Gorham, 1888, p. 82, pl. 5 (fig. 5).

Scaeothe opacus Schaeffer, 1915, p. 236.

Diagnostic description: Coloration carbonaceous black; palpi, tarsi, and five basal antennal segments somewhat lighter. Overall shape

somewhat more obtusely rounded anteriorly than posteriorly, length to width ratio about 2.1 to 1. Body covered with fine minutely reticulate microsculpture that destroys the nitidosity. Pronotum subquadrate, widest before base, sides evenly, even though feebly, arcuately convergent anteriorly. The pronotal apex feebly convex between the apical angles when the four pronotal angles are in equal focus. Pronotal and cephalic punctures moderately strong and deep, rather uniform in size and density, mostly separated by about the distance of their diameters. Elytral intervals distinctly punctulate, scutellum similarly punctulate. Metasternal and abdominal coxal lines present but fine and weak.

Variation: The observed size range in mm is 2.19 to 2.21 in width, and 4.49 to 4.65 in length.

Male genitalia: The aedeagus is similar to that of *H. elateroides* in general characteristics but the tegminal arms bear distinct dorsal lobes medially (see Boyle 1956, fig. 137); also, the enclosed ejaculatory duct is of a much larger diameter, and the median lobe is scarcely membranous dorso-apically. The anterior end of the internal sac is distinctive (see Boyle, 1956, fig. 138).

Biology: Nothing is known of the biology of this form.

Published illustrations: The adult is figured by Gorham, 1888 (1887-1899, pl. 5: fig. 5).

Type: Not seen.

Type-locality: Toluca, State of Mexico, Mexico.

Distribution: MEXICO: Mexico: Toluca (type-locality). Oaxaca: Oaxaca, July 15 to 21. Sonora: Bokachaka, Río Mayo, July 5. UNITED STATES: Arizona: type-locality of *Scaeother opacus* Schaeffer.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3602

The Crayfishes and Their Epizoötic Ostracod and Branchiobdellid Associates Of the Mountain Lake, Virginia, Region ¹

By Horton H. Hobbs, Jr., Perry C. Holt,
and Margaret Walton ²

The Mountain Lake Region, as here considered, comprises approximately 500 square miles (1290 square km) in Craig, Giles, and Montgomery Counties, Va., and Monroe County, W. Va. Here the altitude varies from 396 m (1300 ft) at New Castle, Craig County, to 1329 m (4363 ft) at Bald Knob on Salt Pond Mountain in Giles County. Waters draining from the area contribute to three major river systems—the New River flowing to the Ohio and Mississippi Rivers, the James River to Chesapeake Bay, and the Roanoke River to Albemarle Sound, N.C.

Except for a few sphagnum bogs, sinkhole ponds, and impounded streams, the only lentic habitat larger than a few feet in diameter is the oligotrophic Mountain Lake situated at an elevation of 1180 m,

¹ A contribution from the Mountain Lake Biological Station of the University of Virginia and the Department of Biology of the Virginia Polytechnic Institute. The branchiobdellid studies were supported by grants (NSF G 4439, G-9828, GB-372) from the National Science Foundation.

² Hobbs: Smithsonian Institution; Holt: Virginia Polytechnic Institute; Walton: Mountain Lake Biological Station.

with a surface area of 0.2 square km and a maximum depth of 31.5 m (Roth and Neff, 1964, pp. 5, 8). Of these, collections were made only in Mountain Lake.

The streams vary in size from tiny spring rills cascading over rocky and sandy bottoms to the 161-meter-wide New River, which courses with a moderate current over bedded limestone and discharges from 1186 to 35,228 cubic feet per second at the Eggleston Gauging Station (average annual minimum and flood flows from 1930 to 1958) (Ross and Perkins, 1959, p. 6).

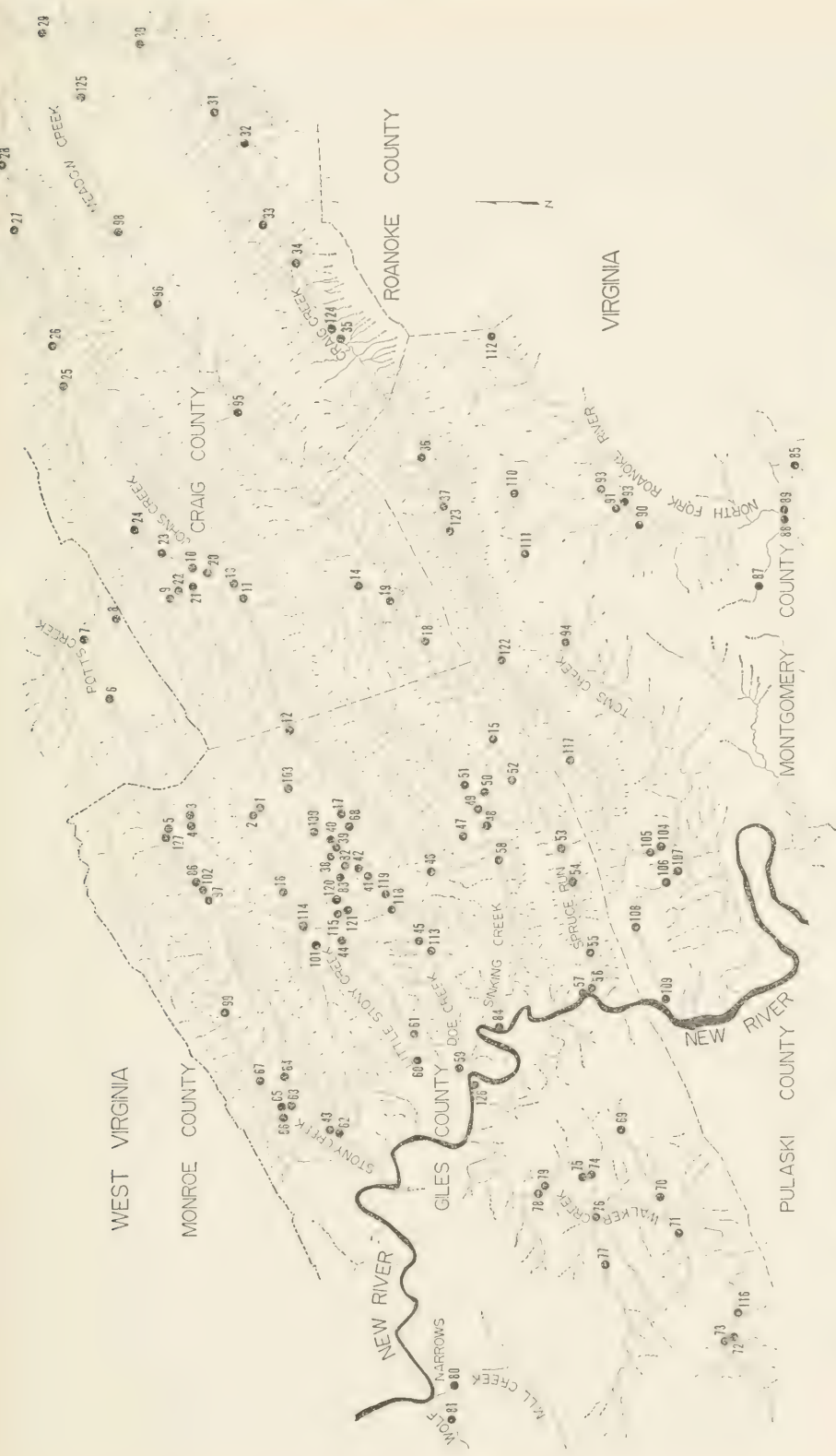
In much of the area, sandstones of the Silurian Age overlie Ordovician limestones and shales, and at higher elevations the waters flowing over the exposed sandstones have a total hardness of as little as 4 ppm. Some streams at lower elevations, passing over and through channels in calciferous rocks, accumulate soluble carbonates to the extent that in the larger valley streams the total hardness may attain concentrations of as much as 142 ppm (Shoup, 1948). In one stream (sta. 85) the M.O. alkalinity reaches 350 ppm.

The midsummer temperature of one of the springs (sta. 68) located at an elevation of 1219 m is 13° C, and that of the valley streams may rise to 26.7° C (Shoup, 1948).

Physiographic, hydrographic, and ecological data for several of the streams sampled in this study may be found in Burton and Odum (1945), Ross and Perkins (1959), and Shoup (1948).

Precise numbers of specimens examined during the course of the survey are not available; however, records include some 2700 crayfishes, 5200 ostracods, and 1600 branchiobdellids.

COLLECTION TECHNIQUES AND DISPOSITION OF SPECIMENS.—This study was initiated during the summer of 1960 and collections have been amassed during each of the succeeding summers through 1965. One hundred and twenty-seven stations (see map 1) were established in the area, and collections of the crayfishes were made by hand from open water or burrows and with the aid of minnow seines. In most instances all of the crayfishes collected from one station on a given day were killed in 6 to 10 percent formalin in a single container. In the laboratory, the ostracods and branchiobdellids were recovered from the bottom of the container and prepared for identification. All of the species (crayfish, ostracods, and branchiobdellids) found in that collection were considered to be associated and were so recorded. In instances wherein there was a question as to whether or not a particular ostracod species actually lived upon the exoskeleton of a particular species of crayfish, that species of crayfish was recollected, preserved alone, and the ostracods recovered from that collection were then known as associates. In that manner it was determined that the assumed associations were highly probable. In order to determine the abundance and distribution of certain sym-



MAP 1.—The Mountain Lake, Virginia, Region with drainage systems and collecting stations referred to in this study.

bionts on the crayfish host, the crayfish was killed, dissected into units, and the specimens from each unit separately preserved.

Most of the crayfishes and ostracods on which this study is based are in the collections of the U.S. National Museum; the branchiobdellids are in the collection of Holt, but most of these will be deposited in the same museum.

PRESENTATION OF DATA.—Brief discussions of the habitat, population sizes and fluctuations, and food habits of each of the three groups precede the sections devoted to the individual species. Within the discussions devoted to each group, brief accounts of the anatomical features utilized in the identification of the species are followed by illustrated keys and generic diagnoses. For each species, a diagnosis, the range, the distribution in the area, and the drainage systems, range of elevations, and associates are presented. Data relative to associations are summarized in table 1, and a discussion of those associations concludes the study.

ACKNOWLEDGMENTS.—We should like to express our appreciation to the following persons who assisted us on one or more of our collecting trips in the Mountain Lake region: Messrs. Paul Buhan, J. E. Carico, C. J. Freeman, R. H. Gilpin, H. H. Hobbs, III, H. A. James, E. P. McConnell, Dr. F. A. Marland, Mr. Homer Mumaw, Dr. John J. Neal, Jr., Dr. Jean E. Pugh, Miss Lucile Walton, Mrs. Shirley Wells, and Miss Mary Lou Wood. Also, we are grateful to Dr. Robert D. Ross for his discussions of stream piracy and problems of distribution of fishes in the area.

The Habitats

THE CRAYFISHES.—Of the six species and subspecies of crayfishes in the area, four vie for the habitats provided by tributaries of the James River (Hobbs, 1951). In the uppermost reaches of both headwaters and lateral tributaries, almost without respect to altitude, *Cambarus b. bartonii* is the sole inhabitant and utilizes cover provided by rocks, roots of shoreline plants exposed in the water, and most debris occurring within the stream bed. As the stream begins to exhibit alternating riffles and pools, in contradistinction to cascading areas and pools, *C. l. longulus* takes over the major portions of the riffles while *C. b. bartonii* occupies the pools and takes advantage of the rock cover along the margins of the riffles. Downstream, as the alternating pool and riffle areas become more pronounced and more extensive, *C. acuminatus* replaces *C. b. bartonii* in the pools and is frequently abundant immediately above and below the riffles, utilizing, for the most part, cover provided by the larger rocks. In the areas where the three may be found, *C. b. bartonii* seeks the marginal portions of both the riffles and pools and frequently con-

structs tunnels in the bordering banks. As might be expected, none of the three recognizes any absolute limits such as suggested, and occasional individuals of each may invade the ecological niche of the other two. To what extent these invasions are due to individual wanderings, intraspecific population pressures, or interspecific pressures, is not known. Of the three there seems to be little doubt that *C. l. longulus* is ecologically more restricted than either of the other two. At lower elevations, particularly in the larger streams in which there are larger rocks in the riffle areas, *C. acuminatus* not only appears to compete with *C. l. longulus* but frequently replaces it. *C. b. bartonii* undoubtedly has the broadest ecological tolerance, and in the New River drainage, where it is not in competition with *C. l. longulus*, it is as abundant in the riffle areas as in the pools and marginal portions of the stream. Furthermore, in the tidewater areas of Virginia, *C. b. bartonii* is found not only living in the smaller streams but also burrowing in swampy areas along the margins of streams. In the Roanoke drainage system, the ecological distribution of *C. b. bartonii*, *C. l. longulus*, and *C. acuminatus* is not unlike that indicated in the James River drainage above; however, the headwater streams are not at such high elevations.

The fourth species, *Orconectes juvenilis*, occurs in two quite dissimilar habitats in the Mountain Lake area. At the present time it is the only crayfish found in Mountain Lake itself, and apparently it is found in most of the littoral zone, where adequate cover exists in the form of stones and rubble. In the single Potts Creek locality, it occurs primarily in precisely the same types of habitats in which *C. acuminatus* is found elsewhere in the James drainage, and in addition it has invaded the riffle zones frequented by *C. l. longulus*. In the portion of the New River system treated here, *O. juvenilis* is restricted to Mountain Lake, having been introduced there in 1933 (Hobbs and Walton, 1966a). *Cambarus b. bartonii* and *C. sciotensis* share the remainder of the watershed in the area. As in the James drainage, *C. b. bartonii* is the sole inhabitant of the headwater streams, and downstream, where it encounters populations of *C. sciotensis*, it is confined to the marginal regions, but even there, apparently it competes for cover with the latter. In Little Stony Creek, both species occur up to the level of station 44, where the cascades serve as a barrier to *C. sciotensis* (and probably to the upstream migration of *C. b. bartonii* as well); above the cascades, *C. b. bartonii* is the sole crayfish inhabitant and it occupies all portions of the stream bed. In accessible areas of the New River system, it appears that *C. sciotensis* vicariates for *C. acuminatus* and in part for *C. l. longulus*.

While all the crayfishes of the area demonstrate some burrowing tendencies, only *C. carolinus* spends the greater part of its life living

in burrows or wandering over land on humid evenings. In all of our collections no specimen has been collected from a stream, pond, or puddle, and most were found at night either wandering above ground or were taken from the mouths of their burrows. A few were dug from their branching burrows.

In the smaller creeks, *C. b. bartonii*, *C. l. longulus*, and *C. acuminatus* all burrow in the stream beds during the winter months as they do if the water level in the streams becomes low at other seasons. Seldom does *C. b. bartonii* seem to be content simply to crawl beneath a rock unless it is a rather large one. Even then evidence of excavation may be seen. *Cambarus sciotensis*, *C. acuminatus*, and *O. juvenilis* apparently exert far less effort in digging than do *C. b. bartonii* and *C. l. longulus*, but neither of the latter is so typically associated with burrows as is *C. carolinus*.

THE OSTRACODS.—With only one exception (*Uncinocythere bicuspidata* on a freshwater crab of the genus *Pseudothelphusa* in Mexico: Hobbs and Villalobos, 1958, p. 395), ostracods of the subfamily Entocytherinae seem to be confined to the exoskeleton of crayfishes. Marshall (1903) reported *Entocythere cambaria* from the gill chamber of a crayfish collected at Madison, Wisc. In 1926, Sars described *Cytherites insignipes* (the second known member of the subfamily) from three female specimens collected in Canada but had no further data for them. Klie (1931) described *E. donaldsonensis* (= *Donnaldsoncythere donaldsonensis*) from Donaldson's Cave, Lawrence County, Ind., but did not indicate that it was associated with a crayfish. Rioja (1940a, pp. 593, 594; 1941, pp. 193, 194) indicated that the habitat of *E. heterodonta* (= *Ankylocythere heterodonta*) is quite different from that of Marshall's species inasmuch as the animals are found rarely in the branchial chamber; instead, most of them occur on the outer surface, clinging to the setae. Dobbin (1941, p. 185) reported her *E. columbia* (= *Uncinocythere columbia*) "from crayfish branchiae." Hoff (1942, pp. 63–65) implied that the primary infestation of the ostracods is in the gill chambers of the crayfish, for, in his "Methods," he indicated that "the ostracods will leave the gills of the host if the crayfishes are placed in a vessel containing 95% ethyl alcohol." He did not indicate that he found them elsewhere on the crayfish, but he did state that he found them "in the water of crayfish burrows." Kozloff and Whitman (1954, p. 159) reported that *E. columbia* and *E. occidentalis* (= *U. columbia* and *U. occidentalis*) "occur principally among the cuticular hairs on the ventral side of the thorax of the host, but a few are found among the mouth parts and on the branchiae." Kozloff (1955, p. 156) indicated that *E. erichsoni* and *E. caudata* (= *U. erichsoni* and *U. caudata*) that remained on their hosts after preservation "were found primarily among the cuticular hairs on the ventral

side of the thorax. A few were taken from the mouth parts." In studying the incubation and hatching of the eggs of *E. illinoisensis*, Stamper (1957, p. 50) reported that 90 percent of the crayfishes examined carried eggs of the ostracod "attached to the hooked setae and/or the coxal filaments. Both of these structures are located underneath the carapace of the crayfish." Westervelt and Kozloff (1959, p. 239) stated that *E. neglecta* (= *U. neglecta*) occurs principally on the same areas of the crayfish as *U. erichsoni* and *U. caudata*.

Two of us (Walton and Hobbs) have attempted to discover whether or not several of the species in the Mountain Lake area are limited to certain anatomical regions of their crayfish host. As might be expected, they are not found on exposed surfaces except where there are setae to which they may cling or grooves in which they may obtain support. Particularly do they seem to congregate on the gnathal appendages, where, on occasional crayfishes, scores of them may be found moving about or clinging to the setae. Far fewer individuals are found among the articular membranes and setae associated with the ambulatory appendages, but certain species are more abundant on the abdomen. Not one ostracod has been observed in the branchial chambers of the crayfishes examined! There seems to be no absolute specificity of microhabitat on the crayfish for any of the ostracods observed although if two or more species occur on the same crayfish, as they frequently do, one may be found more abundantly in one area than elsewhere. We have found, for example, that in the associations of *Asectocythere asecta* and *Dactylocythere chalaza* on *Cambarus carolinus*, the latter is more abundant on the abdomen and *As. asecta* among the gnathal appendages.

None of the ostracods in the Mountain Lake area occurs in all parts of any of the drainage systems and, although they are obviously subject to restrictions, no analytical data are available to demonstrate the nature of these limiting factors. Two of the species, *As. asecta* and *Dt. chalaza* are confined to the exoskeletons of the burrowing crayfish, *C. carolinus*, which tunnels its way to ground water. Whether it is the absence of competition with other ostracods, the groundwater habitat, an obligate relationship with the crayfish, or a combination of, or none of, these factors that is restricting these ostracods remains to be demonstrated. Altitudinal correlations exist with at least two of the species—*Donnalisonocythere sealis* has not been found below approximately 670 m, and *Ankylocythere ancylla* above 475 m; however, it is unlikely that altitude is serving directly as a barrier to them. To our knowledge, not a single limiting factor in the ecological distribution of any entocytherid has been identified.

If, as generally conceded at the present time, the ostracods of the

Entocytherinae are not parasitic on their crayfish hosts, there seem to be few reasons why one might expect host specificity to have developed. Nevertheless, there are a few species that have been found only on one host. This apparent specificity is more probably related to the the habitat of the crayfish than to other factors, for in most of these associations a burrowing crayfish is involved, either *C. carolinus* or *C. d. diogenes*. Of the nine species of the genus *Asectocythere* (see Hobbs and Hart, 1966), five of them have been found only on *C. carolinus*; both species of the genus *Plectocythere* are restricted to the same crayfish; and the three species of the genus *Gcoocythere* (see Hart, 1959, 1965) and the monotypic *Rhadinocythere* (see Hart, 1965) have been found only on *C. d. diogenes*. In the Mountain Lake region, *As. asecta* and *Dt. chalaza* share a single host, *C. carolinus*.

THE BRANCHIOBDELLIDS.—The branchiobdellids are epizoites known from several holarctic freshwater crustaceans, principally decapods of the family Astacidae, but they have been recorded from freshwater crabs (Hobbs and Villalobos, 1958, p. 395; Holt, 1964, p. 2), freshwater shrimp (Liang, 1963, pp. 569, 570), and a cave isopod (Holt, 1963, p. 99). All attach to the exterior surface of the host by means of a posterior sucker and move from place to place on the host's body in a leechlike fashion, using the peristomium as an anterior sucker. All of the branchiobdellids considered here are from crayfishes.

Most species of branchiobdellids are not found in all parts of the streams of a drainage system in which they occur. There are, presumably, ecological factors regulating such distributional patterns; but in general it is not known what these factors are, though Berry and Holt (1959, p. 7) showed a difference in the temperature responses of *Xironogiton instabilis* and *Xironodrilus formosus*, which suggests that an intolerance of high temperatures may operate in confining *Xg. instabilis* to the colder streams of higher elevations.

The occurrence of several species of branchiobdellids (as many as six) on the same host animal has raised the question as to whether or not a particular species is confined to a specific part of the body of the host. Holt (1954, p. 170) first called attention to the problem presented by the possible existence of microhabitats for branchiobdellids on the crayfish hosts. McManus (1960, p. 422) studied three species of branchiobdellids, *Xg. instabilis*, *Cambarincola philadelphia*, and *C. fallax*, all of which occur in the Mountain Lake area) from Fall and Cascadilla Creeks in New York, and his observations are in accord with those of Brown (1961, p. 25), who has studied, from Sinking Creek, the microhabitats of 6 of the 12 species of branchiobdellids that occur in the Mountain Lake area. Though a more rigorous control of his statistical procedures would have been desirable, there is no reason to doubt his general conclusions: (1) the microhabitat

of *C. branchiophila* is within the gill chambers of the crayfish; (2) *Ankyrodrilus koronaeus* (his species X) is primarily an inhabitant of the chelipeds; (3) *Pterodrilus aleicornus* is randomly distributed over the ventral surface of the crayfish; (4) *C. fallax* is essentially confined to the basal segments of the pereopods and antennae; (5) *C. ingens* occurs principally upon the ventral surface of the abdomen and along the cervical groove, but competes with *C. fallax* so that, when one species is common upon a crayfish, the other is rare; (6) *Xg. instabilis* is found almost always on the chelipeds. Of the other species included in this study, *Bdellodrilus illuminatus* is known beyond doubt to be a gill-inhabiting form; it is assumed that the microhabitat of *A. legatus* is that of its congener and that these two species are allopatric; *Xd. formosus*, on the basis of our field experience, is a species of the exterior surface of the branchiostegites of the crayfish; and little or nothing can be said of the microhabitats of the remaining species (*C. heterognatha*, *C. philadelphica*, and *C. holostoma*), though we suspect that *C. philadelphica* and *C. holostoma* may occupy essentially the same microhabitats as *C. fallax* and *C. ingens*.

Goodnight (1940, p. 65) and McManus (1960, pp. 424-427) have, among others, considered the question of host specificity among the branchiobdellids. Goodnight reviewed the host records presented by previous workers and said, "In short, within the limits of the range of any branchiobdellid any crayfish may serve as host." McManus found it surprising that branchiobdellids should have the broad ecological tolerances attributed to them and attempted to study this problem in New York from an area where there are three species of branchiobdellids and four of their crayfish hosts. He found very few worms and no cocoons on *Orconectes p. propinquus*, confirmed by experimental procedures that *O. immunis* is an unsatisfactory host for *Cambarincola philadelphica* and *C. fallax* (lumped together by him as *Cambarincola* species), noted that all subadults and adults of *Cambarus robustus* carried either worms or cocoons, and observed that *C. b. bartonii* is very commonly infested. Lytle (pers. comm.) reports a similar finding for branchiobdellids from central Pennsylvania.

Populations

THE CRAYFISHES.—No quantitative data on crayfish populations in the area are available, but it is readily apparent that population sizes vary tremendously from stream to stream and even from year to year in corresponding seasons. Unfortunately, in this study observations were largely confined to the summer months, and most seasonal fluctuations, if they occurred, might well have escaped detection. Admittedly, in certain instances the fluctuations are more apparent than real; for example, it is highly unlikely that there are fewer indi-

viduals of *Cambarus l. longulus* in a given riffle area in January than in April. Utilizing the usual collecting techniques, however, it is very difficult to obtain even a dozen specimens during the winter months; in the early spring the collectable individuals are mostly males and yearling females; a little later in the spring the adult females appear in the population so that an approximation of the population size cannot be obtained until late spring. In late fall the population begins to diminish in size and by winter it has almost disappeared. This fluctuation is obviously a result of the habits of the species in burrowing below the frostline before the stream freezes and, although the males and yearling females emerge in early spring, the adult females remain in the burrows until their eggs (laid in late winter or early spring) have hatched and the young have left or are ready to leave their mothers. Although year-round data are not available on any of the crayfishes in the Mountain Lake area, Smart (1962) and one of us (Hobbs) have not observed appreciable changes in populations in Swift Run in Greene County, Va., over a 10-year period.

In contrast to the seasonal fluctuation of populations of *C. l. longulus*, the collectable population of *C. sciotensis* in Sinking Creek exhibits little fluctuation throughout the year and from year to year, and the same is true for many populations of *C. b. bartonii*.

Adequate data are not available to assess the population sizes in various localities, but possible effects of competition are emphasized in (1) the natural experiment in Little Stony Creek above the Cascades, which *C. sciotensis* has not been able to ascend (here, without competition, *C. b. bartonii* occurs in much larger numbers than in similar streams where it occurs with *C. sciotensis*), and in (2) Mountain Lake, where the introduced *O. juvenilis* has displaced the introduced *C. acuminatus* and the native *C. b. bartonii* (Hobbs and Walton, 1966a).

Perhaps the most exciting observations of competition between species in the area are those that are in progress in Potts Creek. In 1960, two of us (Hobbs and Walton), together with several others whose help has been acknowledged above, visited station 7 and within a few minutes collected 12 specimens of *C. b. bartonii*, 10 of *C. l. longulus*, and 12 of *O. juvenilis*. In 1965, one of us (Walton) returned to this locality and this time collected 94 specimens of *O. juvenilis* and a single specimen of *C. b. bartonii*; not one individual of *C. l. longulus* was to be found! There is no record of *O. juvenilis* having been intentionally introduced into the headwaters of Potts Creek and presumably fishermen collecting their "crawfish bait" in West Virginia released excess animals in the creek, thus stocking a population that not only has become successfully established but is in the process of replacing the native species as it has done in Mountain Lake. In an

earlier draft of this paper, we wrote concerning the Potts Creek locality, "Here, in the single known locality, it [*O. juvenilis*] was found with *C. b. bartonii* and *C. l. longulus* but occurring in an area that might well have been inhabited by *C. acuminatus*. This is perhaps significant in light of the account of the occurrence of *O. juvenilis* in Mountain Lake." With the apparent expulsion of most of the *C. l. longulus* population by 1965, the supposed eradication of *C. acuminatus* prior to 1960, and the apparent inroad on the *C. b. bartonii* population during the intervening 5-year period, the possibility of a rapid spread of *O. juvenilis* in the James drainage system might well be anticipated. Also worthy of note is the fact that, as in Mountain Lake, *C. acuminatus* was supposedly supplanted first, and *C. b. bartonii* is now very poorly represented in the crayfish population. (See further remarks under *O. juvenilis*.)

In 1966, Hobbs and Walton again visited this locality and collected 71 specimens of *O. juvenilis*, 6 of *C. l. longulus*, and 2 of *C. b. bartonii*. Concentrated efforts in selected riffle areas were required to obtain the specimens of *C. l. longulus*, and it seemed obvious to the two of us that there can be no question that the *C. l. longulus* population has been reduced and that the *C. b. bartonii* population has either been reduced or has largely retreated to burrows along the banks of the creek. We do not yet know the range of *O. juvenilis* within Potts Creek but 10 miles downstream from Waiteville, where Route 17 crosses the Creek, the large riffle area there is largely populated by *C. l. longulus*, but *O. juvenilis* is also present. *Cambarus b. bartonii* and *C. acuminatus* were not found. With the absence of the latter, it is probable that even that far downstream, *O. juvenilis* is vicariating for *C. acuminatus*.

It seems unlikely that in any part of the region a lack of food is responsible for depauperate populations, and even in waters low in calcium the crayfishes do not seem less abundant than in those high in calcium. One of the chief limiting factors seems rather to be available cover in the way of loose rocks (as opposed to bedrock), debris, and suitable banks into which the crayfish may burrow. For example, in suitable riffle areas within the range of *C. l. longulus* (James and Roanoke drainages), populations proportional to the size of the riffle and number of rocks of diameters greater than 10–100 mm have been invariably encountered. In contrast, in areas where the water flows rapidly over scoured bedrock, not a specimen of *C. l. longulus* or any other crayfish is to be found. Except in the upper portions of streams that are subject to being converted to a series of pools in dry seasons (such as the upper portion of Craig Creek, sta. 122), the oxygen content (sometimes a limiting factor) of most of the streams in this area approaches saturation throughout the summer.

The only known instance of actual fluctuation of a population in the area is one of *C. sciotoensis*, which occupied the riffle area on Sinking Creek just below the bridge on State Route 700. Since this is a readily accessible area for obtaining crayfishes for experimental work at the Mountain Lake Biological Station, hundreds of specimens were removed during one summer, and the following spring, hours of work in the riffle revealed very few adult individuals. It was not until early fall that the population seemed to have recovered.

THE OSTRACODS.—Although the population size of ostracods on a single crayfish is unpredictable, there are few crayfishes in this area that do not harbor a number of ostracods. A single female specimen of the burrowing crayfish, *Cambarus carolinus*, was infested with 238 ostracods (*Dactylocythere chalaza* and *Asctocythere asceta*); however other individuals of the same species from the same locality had as few as a dozen. Thirty-five ostracods were recovered from a specimen of *C. b. bartonii* with a carapace length of only 14 mm.

It is not known at what age the young crayfish may become infested but apparently they are susceptible to harboring the ostracods within a short time after leaving the parent. The smallest crayfish observed to be infested was *C. b. bartonii* with a carapace length of 12 mm carrying a single individual of *Donnaldsoncythere scalis*.

Repeated observations of infestations of "soft" crayfishes examined shortly following a molt indicate that the ostracods respond to the molt by leaving the old exoskeleton and making their way to the new one. This reinfestation is undoubtedly more nearly assured because of the fact that in this area most of the crayfishes devour their old exuviae, thereby bringing any ostracod remaining on it close to the vulnerable gnathal appendages of the freshly molted host.

It is not known how crayfishes become infested nor are data available to indicate that the population of ostracods increases with time following a molt or that population size diminishes with a molt.

In some portions of the area, a single crayfish may be infested with only one species of ostracod, but, more frequently, at least two species, and often more, occur on a single host; in such instances, they may tend to be concentrated on one area of the host's exoskeleton but there are other associations in which one of the ostracods may occur with equal frequency on the setae of the gnathal, ambulatory, or natatory areas.

Many of the ostracods are infested with peritrichous ciliates; colonial (Epistylidae) and solitary stalked forms are found on the appendages between the valves, and the external surfaces of the valves are often inhabited by members of the family Urceolariidae.

THE BRANCHIOBELLEIDS.—Branchiobdellids may occur in large numbers on a single adult crayfish and there are few crayfish in the

area that do not carry at least a few worms. Brown (1961, p. 7, table iv) collected 100 crayfish from Sinking Creek and recovered from them an average of 106 worms of all species per crayfish. This is, by far, too high an average for all the crayfish in the stream since Brown chose only large and not recently molted crayfish for his studies.

In this study, we present under "Specimens Examined" the number of animals actually studied, selected in most cases from much larger numbers. The collecting methods we used were not such as to allow us readily to determine the number of worms per crayfish, but several times one of us (Holt) has counted over 200 worms from a single crayfish from other areas.

Little is known as to seasonal fluctuations in branchiobdellid populations. Young (1966, p. 576) has found that branchiobdellid populations decline in the winter, which is in agreement with our experience that, when crayfish can be taken, branchiobdellids and their cocoons are almost always present. Some exceptions to this are known: in streams polluted with waste from coal mines, branchiobdellids disappear before crayfish do; although crayfish (*C. b. bartonii*) are present in the upper reaches of Little Stony Creek above the Cascades, branchiobdellids are often rare, perhaps because of the effect of severe winter temperatures or of lowered pH values in the boggy headwaters of the stream; and branchiobdellids are usually absent from recently molted crayfish and almost invariably so from very small animals. The scanty available evidence, then, is not adequate to form a basis for statements about fluctuations of branchiobdellid populations.

Little is known likewise about methods of infestation, and what is known is due mostly to the efforts of McManus (1960, pp. 422-424). He found that the worms apparently do not move to the host when the old exoskeleton is shed in molting and that the young crayfish are not infested with worms for some time after leaving their mother, conclusions supported by our observations and those of Young (1966, pp. 573-574). Apparently crayfish obtain worms when they come in contact with another animal bearing them. It must be noted, however, that these conclusions are not in accord with ours concerning the infestation of crayfishes by ostracods. Especially striking is the presence of ostracods and the absence of branchiobdellids on freshly molted hosts.

As is true of the ostracods, the epizoid branchiobdellids carry in turn their burden of epizoides: peritrichous protozoans. In addition, some of the larger branchiobdellids of the area are parasitized by an unidentified organism, which is found usually as a spherical mass embedded in the worm's body wall tissues. Protozoologists who

have seen this parasite think it may be a fungus; mycologists have shown a preference for regarding it as a protozoan. Nothing else is known of it.

Food Habits

THE CRAYFISH.—No concentrated effort has been made to determine what the crayfishes of the area feed upon, but on the basis of a few observations it seems that the chief item of their diet is decaying plant fragments. Both in the laboratory and in the streams, the crayfish seem readily to accept whatever animal material becomes available; occasional individuals have been observed feeding on fish and insect larvae and not a few on crayfish of the same or different species. In the laboratory, they do not scorn fresh plant material such as lettuce. Crayfishes are as nearly omnivorous as any animals ever observed by us.

THE OSTRACODS.—Marshall (1903, p. 118), who described the first known member of the family, *Entocythere cambaria*, was of the opinion that this ostracod lived in the gill chamber of the crayfish host, where it fed on the readily accessible blood flowing through the branchiae. In contrast, Rioja (1940a, p. 593) indicated in connection with his description of *E. heterodonta* (= *Ankylocythere heterodonta*) that this ostracod is rarely found in the gill chamber of the host and that he considered the members of this genus to be "simple epizoario," taking issue with Marshall's belief that *E. cambaria* is a parasite. Rioja (1940b, p. 58) reiterated the opinion that *An. heterodonta* is an epizoötic commensal. In 1941 (p. 194) Rioja, in discussing the same species, indicated that he had observed the feeding process, which involved the use of the terminal claws of the feet and the apical claws of the second antenna in passing "detritus diversos" to the mouth. Hoff (1942, p. 64) also questioned the fact that Marshall's species was parasitic, indicating that Marshall's deduction "based on the belief that the homogeneous mass of material in the intestine of the ostracod is the blood of the host . . . is not valid proof . . . since a homogeneous food mass is found as well in many free-living ostracods." He summarized the situation as follows:

That the *Entocythere* species do feed on material in the water is evidenced by the finding of diatoms and other particulate organic materials in the gut. That the organisms are not strictly parasitic is also shown by the fact that they often for some reason leave the host. Individuals have been found by the writer in the water of crayfish burrows and by Klie (1931) in Indiana cave waters. All of the *Entocythere* species are probably commensal, but at the very most, if parasites at all, are only facultative.

Our observations support Hoff's conclusions and those of Rioja: in living animals both the mandibles and maxillae with their branchial plates seem constantly to be in motion receiving finely divided particles

passed to them by the second antenna. The terminal claws of the latter collect the particles entrapped by the setae of the host. Fecal pellets contain mostly a finely divided brown material (the origin of which is not known), small translucent refractive fragments, portions of diatoms, small rods (presumably bacilli), and what are believed to be spore cases. Furthermore we have not observed a single ostracod among the gill filaments, where, were they parasitic, they would most likely occur.

THE BRANCHIODELLIDS.—There is a persistent tradition that branchiobdellids are parasitic; this is certainly not true of most species, but almost surely it is true of the gill-inhabiting forms. Smallwood (1906, p. 100) found the gut of *Xironogiton instabilis* always full of algae and thought he found the same for *Bdellodrilus illuminatus*. Since the latter is confined to gill chambers, Smallwood probably was dealing instead with a species of *Cambarincola* that is not gill-inhabiting. Hall (1914, p. 189), on the basis of pieces of striated muscle fibers found in the lumen of the intestine, reported that adults of *Ceratodrilus thysanosomus* are parasitic. These fibers, however, probably were derived from ingested insect larvae rather than from the hosts. Goodnight (1940, p. 66) reviewed these and other similar comments and added his opinion that diatoms are the "favorite" food of most species. The truth is that no careful studies of the food and feeding habits have been made. It can, nevertheless, be said of the species encountered in the present study that *Bdellodrilus illuminatus* is parasitic, feeding on the gill filaments of the host; probably the same is true of *Cambarincola branchiophila*. *Pterodrilus aleicornus* is particularly partial to diatoms, which constitute the vast bulk of the food of this species. The larger species of *Cambarincola* show carnivorous and cannibalistic tendencies as well. Whether or not the other species of the area have a specialized diet cannot be said, for all branchiobdellids, except the gill-inhabiting parasites, appear to feed simply by grazing on the unicellular algae, bacterial gloea, and the animals, except the ostracods, that make up the flora and fauna that are borne by crayfishes.

The Crayfishes

The key that is provided for the identification of the crayfishes of the region can be used reliably only in the immediate area. In order to facilitate the rapid identification of specimens of both sexes, the secondary sexual characters that are definitive for generic determinations, and some specific ones as well, have been disregarded.

The male crayfishes of the area, like all members of the subfamilies of the Astacidae except the Astacinae, exhibit a cyclic dimorphism

(Hagen, 1870, p. 21) affecting principally the first pair of pleopods, the hooks on the ischiopodites of the third pereopods, and the chelipeds. In the breeding males, "Form I," the first pleopod has one corneous terminal element, and the hook of the ischiopodite of the third pereopod is developed more strongly and usually more acutely; the cheliped is usually more robust and frequently the crayfish is more vividly colored (ignoring the fact that all freshly molted crayfishes are more brightly colored than at any other time.) The nonbreeding males are designated "Form II."

The life cycle of *Cambarus l. longulus* (see Smart, 1962) is better known than that of any of the other species in the area, and it appears that it does not differ, except perhaps in details, from that of *C. acuminatus* (see Word and Hobbs, 1958, p. 436) and *O. juvenilis*. The young of *C. l. longulus* hatch from the egg in early spring, undergo a series of molts through the summer and fall but cease to grow throughout the winter. The following spring, growth resumes and in September juvenile males molt to the breeding stage (Form I). The first breeding season extends from late fall to spring when the male molts to the nonbreeding stage (Form II). In September it again molts to the first form and passes its second breeding season, molting to the second form in the spring. Most of the males die after the second breeding season but a few undergo one additional molt to the first form in the fall and die in the spring. Females carry their eggs during the late winter and early spring; however, an occasional female will be found in midsummer with a full complement of eggs on the pleopods. It is obvious, on the basis of this brief account, that first form males of *C. l. longulus*, *C. acuminatus*, and *O. juvenilis* are abundant in the late fall, winter, and early spring but are rare at other seasons.

In contrast, first form males of *C. sciotensis*, *C. b. bartonii*, and *C. carolinus* may be collected at almost any time during the year, and females with eggs occur, for the most part, during the summer and fall months. Almost no life history data are available for *C. carolinus* and *C. sciotensis*.

Additional data for all of the crayfishes treated here may be found in the indispensable contributions of Ortmann (1905, 1931).

Key to Crayfishes

- 1 Rostrum with marginal spines; first pleopod of male terminating in two straight rami. **Orconectes juvenilis**
- 1' Rostrum without marginal spines; first pleopod of male terminating in two short rami that are recurved at angles of approximately 90°.

Cambarus . . . 2

2(1') Fingers of chela with weak longitudinal ridges above, broadly gaping and with a conspicuous tuft of setae in gap; rostrum with much thickened, convergent margins; areola with crowded, deep punctations.

C. l. longulus

2' Fingers of chela with well-defined longitudinal ridges above and fingers seldom broadly gaping; if so, then no conspicuous tuft of setae between them; rostral margins may or may not be thickened but, if so, never strongly convergent; areola usually with scattered punctations, if crowded, never deep 3

3(2') Lateral surfaces of carapace with a strong spine on each side immediately posterior to cervical groove; rostrum with margins gently converging mesially along almost entire length; postorbital ridges with spines.

C. acuminatus

3' Lateral surfaces of carapace with or without a well-developed tubercle on each side immediately posterior to cervical groove but never with a strong spine; margins of rostrum always suddenly contracted at base of short acumen; postorbital ridges never with spines at anterior extremities. 4

4(3') Rostrum with thickened subparallel margins suddenly contracting to form right angles (in mature specimens) at base of acumen . . C. sciotensis

4' Rostrum with slender or moderately thickened margins that never form right angles at base of acumen, angles obtuse or contractions rounded . 5

5(4') Areola at least eight times longer than broad; inner margin of palm of chela with cristiform row of tubercles flanked above by at least one or two additional tubercles; color red; and seldom found outside of complex burrows except in evenings after heavy rains when they wander over land C. carolinus

5' Areola never so much as eight times longer than broad; inner margin of palm of chela with single row of appressed tubercles with occasional two or three scattered tubercles flanking it above; color shades of tan, green, or blue but never red; usually found in flowing water under stones or debris or in burrows along banks of streams or ponds. C. b. bartonii

Genus *Cambarus* Erichson, 1846

DIAGNOSIS.—Hobbs (1965, p. 267) stated:

First pleopod of first form male symmetrical and terminating in two or three distinct parts, usually only two (mesial process and central projection) bent caudally or caudolaterally with principal axes of shaft and each ramus forming angles of approximately 90 degrees; if mesial process and central projection directed at angles of less than 90 degrees to main shaft, central projection never comprising more than 1/8 of total length of appendage or bent at angle of less than 45 degrees; central projection corneous and flattened laterally; mesial process mostly non-corneous, frequently inflated; caudal process, when present, forming knob-like prominence at caudolateral base of central projection. Hooks present on ischiopodites of third pereopods only except in *Cambarus dissitus* Penn (1955, p. 73) in which also present on those of fourth pereopods. Opposable margins of ischiopodites of third maxillipeds with teeth.

Cambarus acuminatus Faxon

FIGURE 1

Cambarus acuminatus Faxon, 1884, p. 113.

DIAGNOSIS.—Margins of rostrum gently converging from base to apex, not thickened, and without marginal spines; areola never more than six, usually three or four, times longer than broad with many shallow punctations; suborbital angle acute. Chela with subovate fingers bearing distinct median longitudinal ridges on upper surfaces; fingers not conspicuously gaping and never provided basally with conspicuous tuft of setae; inner margin of palm with two well-defined rows of prominent tubercles.

RANGE.—Atlantic watershed from southern Maryland to South Carolina in the lower mountains, piedmont, and upper coastal plain.

SPECIMENS EXAMINED.—Approximately 235 specimens in 25 collections from tributaries of the James River and North Fork of the Roanoke River in Craig and Montgomery Counties, respectively (sta. 20, 27, 29–33, 35, 87–93, and 112) at altitudes from 402 to 535 m.

ASSOCIATES.—*Cambarus acuminatus* was collected with *C. l. longulus* at all of the stations except 87 and with *C. b. bartonii* except at 20, 27, 30, 31, 33, 88, 112.

In the James drainage, ostracod associates include *Dn. ardis* at stations 20, 27, 30–33, 35; *Dn. ilcata* at 20, 29, 31–33, 35; *Dt. suteri* at 27, 30, 31, 33, 35; *E. internotalis* at 30, 31, 35; and in the Roanoke drainage the latter at 88, 90; *An. ancyla* at 88, 89, 92, 93; *Dn. truncata* at 87, 88, 90, 91, 93; and *Dt. falcata* at 87–93, 112.

In the James drainage branchiobdellid associates include *C. philadelphia* at stations 20, 27, 29, 32, 33, 35; *A. koronaeus* at 29, 30; *C. branchiophila* at 20, 29; *B. illuminatus* and *C. holostoma* at 20; and in the Roanoke drainage *A. koronaeus*, *C. branchiophila*, and *C. philadelphia* at 87–93, 112; *B. illuminatus* at 87; *C. fallax* at 87–89, 91, 92; and *Xd. formosus* at 88–92, and 112.

REMARKS.—This species is more abundant in the larger streams in the Roanoke and James drainages, where it occurs in pools, under larger stones, in debris among the marginal vegetation, and in submerged tangles of roots along the banks. It is also found in tunnels along the shore, particularly in areas where there are steep clay banks on the outer sides of bends in the stream. In the Mountain Lake area it shares such habitats with *C. b. bartonii*.

Like *C. l. longulus*, most of the population of *C. acuminatus* disappears from the shallow water of streams in November and does not reappear until spring. Most, if not all, of the individuals retreat into burrows that presumably they construct with the onset of cold weather.

In Virginia, first form males have been found every month of the

year; however, from late September to May, most of the adult male population is in the first form, whereas such males are much rarer from June through August. Females with eggs occur from March to July, although they are very rare after mid-June.



FIGURE 1.—Dorsal view of carapace and chelipeds: *Cambarus acuminatus*.

Cambarus bartonii bartonii (Fabricius)

FIGURE 2

Astacus bartonii Fabricius, 1798, p. 407.

Astacus (*Cambarus*) *bartonii* Erichson, 1846, p. 97.

Cambarus bartonii Girard, 1852, p. 88.

Cambarus bartonii bartonii Faxon, 1890, p. 622 [by implication].

DIAGNOSIS.—Margins of rostrum subparallel or slightly convergent to base of acumen where suddenly contracted (but rounded), thickened but without marginal spines; areola never more than six, usually four or five, times longer than broad with widely spaced punctations; suborbital angle usually acute. Chela with subovate fingers bearing distinct median longitudinal ridges on upper surfaces; fingers may be slightly gaping but never provided basally with conspicuous tuft of setae; inner margin of palm with single row of tubercles, occasional specimens with trace of second row or few scattered tubercles.

RANGE.—From New Brunswick, Canada, to northern Georgia; in the southeast mostly in the mountains and piedmont.

SPECIMENS EXAMINED.—Approximately 1200 specimens in 97 collections from 87 stations. Unquestionably this species is more widespread in this area than any of the others for it is found in all three drainage systems and at altitudes from 1219 to 427 m. It was found at all stations except 11, 13, 15, 18, 20, 27, 30, 31, 33, 40-43, 55, 56, 58, 61, 62, 65, 67, 70, 72, 73, 75, 78-81, 84, 86, 88, 102, 104-106, 109, 112, 116, 126, and 127.

ASSOCIATES.—In the James and Roanoke drainages it was associated with *C. l. longulus* at stations 6, 7, 9, 10, 12, 21-23, 25, 29, 32, 34, 35, 37, 89-93, 123, 124; with *C. acuminatus* at 29, 32, 35, 87, 89-93; and with *O. juvenilis* at 7. In the New River drainage it was associated with *C. sciotensis* at Stations 3, 5, 19, 44, 50, 54, 57, 59, 63, 64, 66, 95-97, 107, and 108.

Ostracod associates include *An. ancyla* at stations 89, 92, 93; *Dn. ardis* at 10, 12, 21, 23, 25, 32, 35, 37, 123, 124; *Dn. ileata* at 3-10, 12, 14, 16, 19, 21-26, 28, 29, 32, 34, 35, 37, 44-48, 50-52, 54, 57, 59, 60, 63, 64, 66, 69, 71, 74, 76, 77, 94-99, 107, 108, 110, 113, 117, 119, 122-125; *Dn. scalis* at 1, 2, 7, 17, 38, 39, 44, 68, 82, 83, 100, 101, 103, 114, 115; *Dn. truncata* at 53, 54, 57, 69, 71, 87, 90, 91, 93, 94, 111; *Dt. falcata* at 85, 87, 89-93, 111; *Dt. suteri* at 35, 124; *E. internotalus* at 23, 35, 90; *E. kanawhaensis* at 44; and *P. phyma* at 3, 5, 7, 24, 38, 44, 64, 82, 101, and 103.

Branchiobdellid associates include *A. koronaeus* at stations 14, 19, 29, 52, 69, 71, 77, 87, 89-93, 98, 110, 111, 125; *B. illuminatus* at 5, 16, 17, 19, 22, 34, 44, 45, 48, 51, 59, 68, 76, 87, 97, 115, 120-122, 125; *C. branchiophila* at 24, 29, 34, 57, 63, 66, 87, 89-93, 97; *C. fallax*

at 3, 5, 24, 49, 54, 57, 63, 66, 71, 87, 89, 91, 92, 95-97; *C. holostoma* at 7, 10, 19, 21-23, 25, 37; *C. ingens* at 5, 54, 64, 95, 97; *C. philadelphia* at 3, 5, 8-10, 12, 14, 16, 17, 19, 21, 22, 24-26, 28, 29, 32, 34-37, 39, 44-46, 48, 50-54, 59, 60, 66, 68, 69, 71, 74, 76, 77, 87, 89-94, 98, 107, 108, 110, 111, 113, 115, 118, 119-125; *P. alcornus* at 3-5, 19, 24,



FIGURE 2.—Dorsal view of carapace and chelipeds: *Cambarus b. bartonii*.

25, 63, 64, 66, 74, 76, 95, 97; *Xd. formosus* at 10, 21, 89-92; and *Xg. instabilis* at 3-5, 7, 9, 12, 21, 22, 24, 37, 44, 46, 53, 54, 60, 64, 56, 97, 121, and 123.

REMARKS.—As indicated above, *C. b. bartonii* is the most widely distributed crayfish in the area, abounding in mountain brooks at high elevations; in the smaller feeder streams at lower elevations it is the sole crayfish inhabitant. As the cascading waters give way to alternating riffles and pools or as the small feeder tributaries join or become larger streams, other crayfishes encounter the *C. b. bartonii* populations, and adult of this species, for the most part, occur only along the littoral areas of the stream, where they may be found under stones or burrowing into the banks. The absence of *C. b. bartonii* from the collections in larger streams at lower elevations probably does not indicate its absence from the streams, but only the fact that it is rarer, and its habits at these elevations make specimens much more difficult to obtain.

Especially around springs, where the winter temperatures of the water are not so low as in streams, this species is active throughout the year, and even in the streams it is more easily routed from its lair than is *C. l. longulus*. Where the streams cut steep banks through clay deposits, frequently *C. b. bartonii* and *C. acuminatus* dig tunnels to the extent that the bank below the high water level is riddled with their passageways, thereby hastening the erosion of the bank. During the summer months, when some of the headwater streams are reduced to a series of pools, *C. b. bartonii* digs burrows in the stream bed much like the winter retreats of *C. l. longulus*.

First form males have been collected from April to October and in December. Females with eggs were found in June, July, and August, and with young in August.

Cambarus carolinus (Erichson)

FIGURE 3

Astacus (*Cambarus*) *carolinus* Erichson, 1846, p. 96.

Cambarus carolinus Girard, 1852, p. 88

DIAGNOSIS.—Margins of rostrum slightly convergent to base of acumen, where suddenly contracted to form obtuse angles at base of acumen, neither thickened nor with marginal spines; areola always at least eight times longer than broad with scattered punctations; sub-orbital angle weak and obtuse. Chela with subovate fingers bearing distinct median longitudinal ridges on upper surfaces; fingers only slightly gaping and never provided basally with conspicuous tuft of setae; inner margin of palm with two rows of tubercles.

RANGE.—Not at all understood but reported from Greenville County, S.C., northward in the mountains to Virginia, Pennsylvania,

and Kentucky. At least two color phases are involved, and perhaps two or more races should be recognized.

SPECIMENS EXAMINED.—135 specimens in 12 collections from the following stations: 8, 22, 40, 41, and 127, at elevations of 585 to 1250 meters. Three of these lie in the New and two in the James drainage systems.

ASSOCIATES.—*Cambarus carolinus* was collected with no other crayfish, for it is the only primary burrowing species in the area. There is little likelihood of its being found with any other species in the region except possibly *C. b. bartonii*.

Ostracod associates include *As. asecta* and *Dt. chalaza*, which have been found with no other crayfish except *C. carolinus* and which were with it in all five of the localities in which it was collected.

Branchiobdellid associates include *B. illuminatus* and *C. fallax* at station 40, and only the former at 41.

REMARKS.—While our knowledge of all of the crayfishes in the region is limited, data on *C. carolinus* is almost totally lacking. The rocky soil in the area makes digging for these animals highly impracticable, and most of our specimens were collected on foggy or rainy evenings when the crayfishes had left their burrows and were crawling about in the grass on the golf course (sta. 41) and in the road (sta. 40).

Cambarus carolinus seldom invades bodies of open water. In some 12 years of observing the streams in the area, we have seen only one individual (juvenile) in such a habitat—at Hunters Branch on the grounds of the Biological Station one evening following a heavy rain.

Several attempts to extricate individuals of this species from burrows in the vicinity of the Mountain Lake Biological Station proved totally unsuccessful. The same technique used there, however, was most successful in a cleared, grass-covered area near the junction of White Rock Branch and Big Stony Creek (sta. 127). Taking care not to allow the burrow to become clogged with earth, a shovel was used to open the burrow to the water table, and the water was thoroughly roiled. Within a short time, the crayfish came to the exposed area and its antennae could be seen whipping to and fro just below the surface film. Making a quick grab, the observer caught the animal. In the area of the Biological Station, the crayfish were never observed coming to the exposed opening as they characteristically did here.

The depths of the burrows at station 127 were not determined, but at about 60 cm below the surface some of them contained chambers 15 to 20 cm in diameter. From one large chamber, 12 juveniles (with carapace lengths ranging from 11 to 18 mm) and an adult female, presumably the mother, were taken.

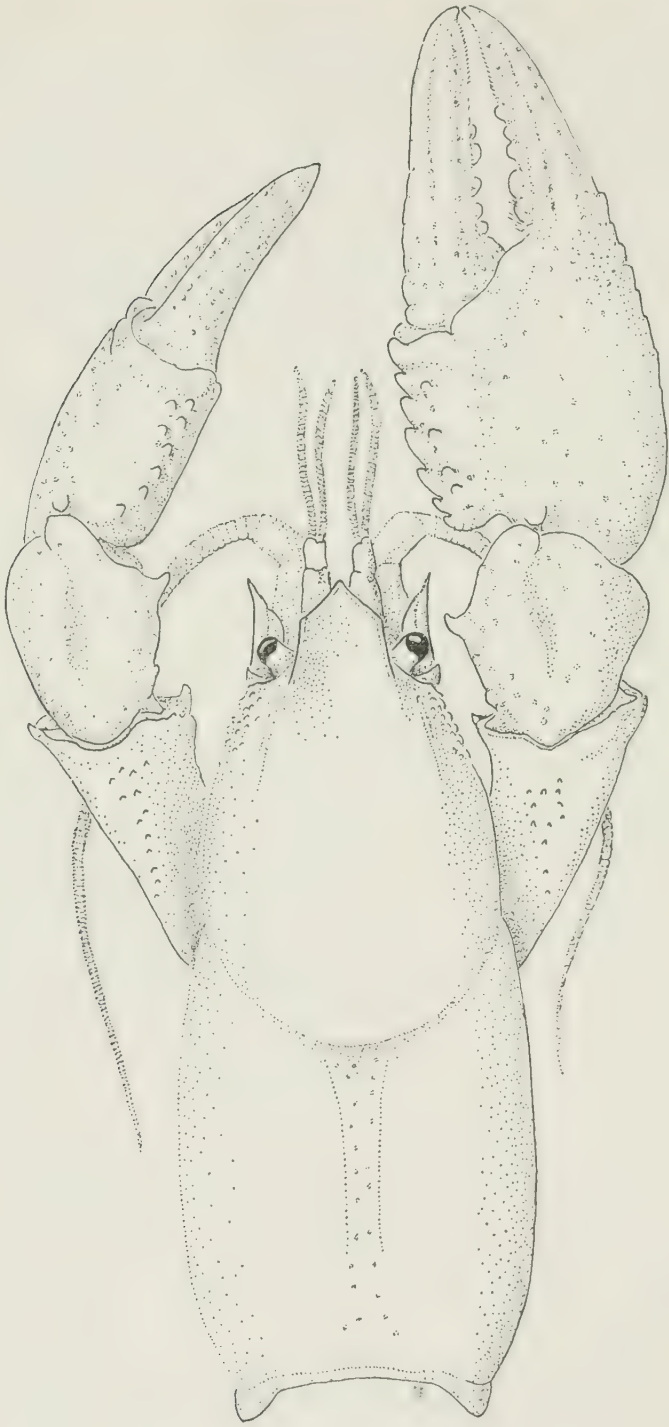


FIGURE 3.—Dorsal view of carapace and chelipeds: *Cambarus carolinus*.

First form males of *C. carolinus* have been collected in the Mountain Lake area in June, July, and August (elsewhere also in April and September through December). A female with eggs was found in June, and the young mentioned above in July.

Cambarus longulus longulus Girard

FIGURE 4

Cambarus longulus Girard, 1852, p. 90.

Cambarus longulus longulus Hay, 1899, p. 959 [by implication].

DIAGNOSIS.—Margins of rostrum gently convergent from base to apex, distinctly thickened and without marginal spines; areola never more than six times longer than broad, usually about three and a half, with crowded deep punctations; suborbital angle lacking. Chela with subcylindrical fingers lacking distinct median longitudinal ridges on upper surfaces; fingers gaping and usually provided basally with conspicuous tuft of setae; inner margin of palm with single, strongly depressed, row of tubercles (frequently scarcely rising above contour of palm).

RANGE.—In the Atlantic watershed from the James River in Virginia to the Yadkin River in North Carolina in the low mountains and upper piedmont provinces. Details of range and variation of this and the other two subspecies of *C. longulus* are discussed by James (1966).

SPECIMENS EXAMINED.—Approximately 450 specimens in 35 collections from the following stations: 6, 7, 9–13, 20–23, 25, 27, 29–35, 37, 88–93, 112, 123, and 124 in tributaries of the James River and North Fork of the Roanoke River in Craig, Giles, and Montgomery Counties, Va., and from tributaries of Potts Creek, Monroe County, W. Va. These stations lie at altitudes between 402 and 686 m.

ASSOCIATES.—Crayfish associates include *C. acuminatus* at stations 20, 27, 29–33, 35, 88–93, 112; *C. b. bartonii* at 6, 7, 9, 10, 12, 21–23, 25, 29, 32, 34, 35, 37, 89–93, 123, 124; and *O. juvenilis* at 7.

In the 23 localities in the James drainage, *C. l. longulus* was found with *Dn. ardis* at stations 10–13, 20, 21, 23, 25, 27, 30–33, 35, 37, 123, 124; *Dn. ileata* at 6, 7, 9–12, 20–23, 25, 29, 31–35, 37, 123, 124; *Dt. suteri* at 27, 30, 31, 33, 35, 124; and *E. internotatus* at 23, 30, 31, and 35. In the seven localities in the North Fork of the Roanoke River, *C. l. longulus* was associated with *Dt. falcata* at all stations (88–93, 112); *Dn. truncata* at 88, 90, 91, 93; and *An. ancyra* at 88, 89, 92, and 93.

Branchiobdellid associates in the James drainage include *A. koronacus* at stations 29, 30; *B. illuminatus* at 20, 22, 34; *C. branchiophila* at 20, 29; *C. heterognatha* at 34, 123; *C. holostoma* at 7, 10, 11, 13, 20–23, 25, 37; *C. philadelphica* at 9, 10, 12, 20–22, 25, 27, 29, 32–35,

37, 123, 124; *P. aleicornus* at 25; *Xd. formosus* at 10, 21; and *Xg. instabilis* at 7, 9, 11-13, 21, 22, 37, 123. In the Roanoke drainage, *A. koronacus*, *C. branchiophila*, and *C. philadelphia* were found at stations 88-93, 112; *Xd. formosus* at 88-92, 112; and *C. fallax* at 88, 89, 91, and 92.



FIGURE 4.—Dorsal view of carapace and chelipeds: *Cambarus l. longulus*.

REMARKS.—This crayfish is the dominant decapod inhabitant of the riffle areas in the James and Roanoke river systems. Except from November to April, this small crayfish can be found in almost every riffle in the lower mountains and piedmont. During the colder months, individuals retreat to their burrows beneath stones in the riffles. At least some of the tunnels descend to depths greater than 30 cm. Because of the sand, gravel, and interlocking stones submerged in the current, it is exceedingly difficult to dissect a burrow. Even though we have removed specimens from such burrows, we are not at all certain that we determined the full extent of the excavations. In the spring, the adult males and juveniles leave the burrows first; the females remain in their tunnels, where presumably they lay and hatch their eggs before venturing into open water. Not until mid-May can one sample the riffle and expect to obtain a knowledge of all the components of the *C. l. longulus* population.

The life history of this crayfish has been briefly outlined above; for details, see Smart (1962).

Cambarus sciotensis Rhoades

FIGURE 5

Cambarus bartoni sciotensis Rhoades, 1944, p. 96.

Cambarus sciotensis Hobbs, 1964, p. 189.

DIAGNOSIS.—Margins of rostrum subparallel or slightly convergent to base of acumen where suddenly contracted to form angles of approximately 90° (or with slightly protruding knobs), thickened but without marginal spines; areola never more than six, usually about four and a half times longer than broad with deep, but not crowded, punctations; suborbital angle obtuse. Chela with subovate fingers bearing distinct median longitudinal ridges on upper surfaces; fingers may or may not be gaping but never provided basally with conspicuous tuft of setae; inner margin of palm with two rows of tubercles.

RANGE.—Apparently discontinuous; in the Scioto River in Ohio and in the New River system in Virginia and southeastern West Virginia (both areas in the Ohio drainage system).

SPECIMENS EXAMINED.—Approximately 450 specimens in 43 collections from the following stations: 3, 5, 15, 18, 19, 43, 44, 50, 54–59, 61–67, 70, 72, 73, 75, 78–81, 84, 86, 95–97, 102, 104–109, 116, and 126. All of them are in the New River drainage system at elevations of 427 to 899 m.

ASSOCIATES.—The only crayfish associate was *C. b. bartonii*, which was found at the following stations: 3, 5, 19, 44, 50, 54, 57, 59, 63, 64, 66, 95–97, 107, and 108.

Ostracod associates include *Dn. ileata* at all stations except 70 and 78; *Dn. scalis* at 44; *Dn. truncata* at 54–57; *Dt. daphnioides* at 70, 72,

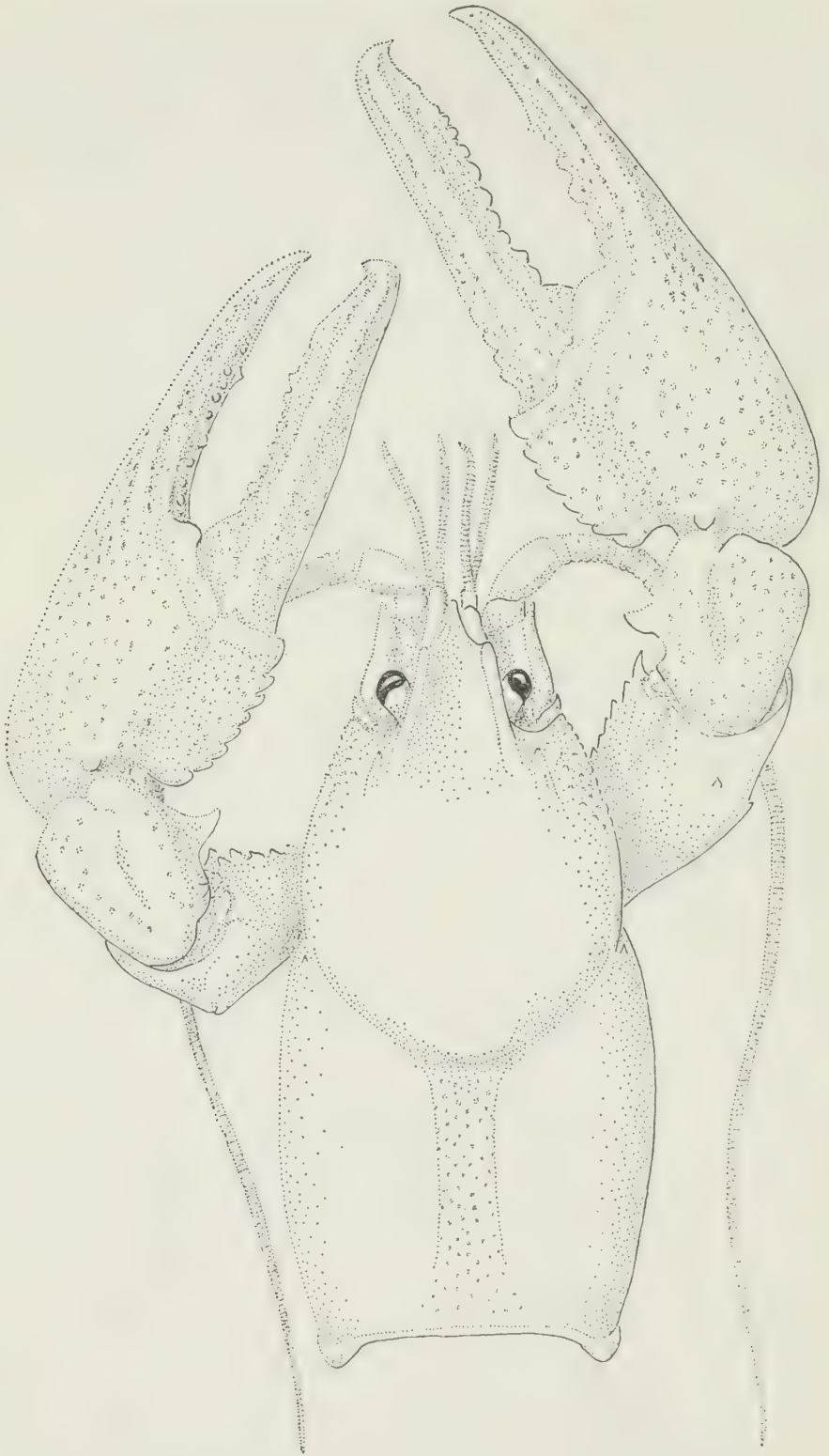


FIGURE 5.—Dorsal view of carapace and chelipeds: *Cambarus sciotensis*.

73, 75, 79–81, 116; *E. kanawhaensis* at 44, 126; and *P. phyma* at 3, 5, 44, and 64.

Branchiobdellid associates include *A. koronaeus* at stations 18, 19, 72; *A. legaeus* at 81; *B. illuminatus* at 5, 19, 44, 59, 86, 97; *C. branchiophila* at 15, 18, 43, 55, 57, 58, 63, 65–67, 72, 73, 75, 79, 81, 86, 97, 104, 116, 126; *C. fallax* at 3, 5, 15, 18, 43, 54–58, 61, 63, 65–67, 70, 72, 75, 78, 79, 81, 86, 95–97, 126; *C. heterognatha* at 3, 5, 61, 63–67, 70, 72, 78–81, 86, 97, 105, 106, 116, 126; *C. holostoma* at 18, 19; *C. ingens* at 5, 15, 18, 54, 58, 61, 64, 67, 70, 72, 73, 75, 79–81, 86, 95, 97, 104, 116; *C. philadelphia* at 3, 5, 19, 44, 50, 54–56, 59, 66, 106–109; *P. alcornus* at 3, 5, 15, 18, 19, 43, 58, 61, 63–67, 70, 72, 73, 75, 79, 81, 86, 95, 97, 104, 105; and *Xg. instabilis* at 3, 5, 44, 54, 61, 64, 86, 95, and 97.

REMARKS.—In the New River system, this crayfish vicariates for *C. acuminatus* of the Roanoke and James drainages, and with the absence of the riffle-inhabiting *C. l. longulus* invades such habitats to a greater extent than does *C. acuminatus*. In marked contrast to *C. l. longulus*, *C. sciotoensis* seems to be active throughout the year, never burrowing except to excavate shallow depressions beneath rocks.

First form males have been collected in March, April, and June to October. Females with eggs were found in July and August, and with young in August.

Genus *Orconectes* Cope, 1872

DIAGNOSIS.—First pleopod of first form male terminating in two parts, which may be straight or gently curved, short or long spines, blades, or subspatulate projections. If terminals bent so much as at right angle, bend never accomplished adjacent to shaft. Male with hooks on ischiopodites of third pereopods and occasionally on those of fourth. Third maxillipeds not conspicuously elongate and ischiopodite with row of teeth along mesial margin.

Orconectes juvenilis (Hagen)

FIGURE 6

Cambarus juvenilis Hagen, 1870, p. 66, figs. 29–33, 157.

Orconectes juvenilis Hobbs, 1942, p. 352 [by implication].

DIAGNOSIS.—Margins of rostrum subparallel or slightly convergent, not thickened, and with pair of marginal spines at base of acumen, upper surface provided with distinct, median, longitudinal carina. Lateral surfaces of carapace with pair of spines immediately caudal to cervical groove; postorbital ridges terminating cephalically in spines; suborbital angles lacking. Inner margin of palm of chela with two closely appressed rows of tubercles with others above. First pleopod of first form male extending cephalad to base of first pereopod when

abdomen is flexed; central projection spiculiform and both it and mesial process straight, the former slightly curved caudally near tip; cephalic surface of shaft with prominent shoulder just proximal to base of central projection. Annulus ventralis with transversely oval depression extending cephalically beneath cephalic wall, latter bearing median cleft.

RANGE.—From Ohio and Kentucky southward to northwest Georgia west of the Alleghenies, and in the headwaters of the James River in Craig County, Va.

SPECIMENS EXAMINED.—300 specimens in 22 collections from stations 7 and 42. The occurrence of *O. juvenilis* in the Mountain Lake area represents two probable introductions (see p. 10 and below), and that at station 7 is the first record of the presence of this species on eastern slopes of the Allegheny Mountains. These stations are located at elevations of 671 and 1180 m respectively.

After this manuscript had been completed, two specimens of *O. juvenilis* were found in the New River, 500 m south of the mouth of Spruce Run in the vicinity of a fishing camp.

ASSOCIATES.—At station 7, *O. juvenilis* was found with *C. b. bartonii* and *C. l. longulus*; in Mountain Lake (sta. 42) it is not accompanied by any other crayfish at the present time.

In station 42, neither ostracods nor branchiobdellids infest the members of this population. At station 7, the ostracod associates include *Dn. ileata*, *Dn. scalis*, and *P. phyma*; the branchiobdellid associates, *C. holostoma* and *Xg. instabilis*.

REMARKS.—With regard to the population of *O. juvenilis* in Mountain Lake (see Hobbs and Walton, 1966a), it is perhaps of interest that in 1933 *C. b. bartonii* was the only crayfish inhabiting it. The latter was, and is still, the only crayfish in the small stream, "Pond Drain," flowing from the Lake. In 1933, members of one of the classes in aquatic biology at the Biological Station brought collections of animals from the vicinities of their homes and released them in the Lake. In 1947, three species were found to be present and with few exceptions were restricted to different regions of the Lake. *Orconectes juvenilis* occurred along the east and to a lesser degree along the south side; *C. acuminatus*, never observed by us to be abundant, was found only along the north side and never closer than 100 yards from the outlet; *C. b. bartonii* was found in the area of the outlet, at the northwest corner. According to our observations, crayfishes have never been abundant along the west side (perhaps they are inaccessible because of the greater depth of the water), and we have no records of what species, if any, frequent this area. By 1954, there were no *C. acuminatus* to be found in any of the littoral areas, and it seemed that *O. juvenilis* was invading the north side;



FIGURE 6.—Dorsal view of carapace and chelipeds: *Orconectes juvenilis*.

C. b. bartonii was still present in the vicinity of the outlet, but occasional individuals of *O. juvenilis* were also there. Since 1957, no crayfish except *O. juvenilis* has been observed by us in the entire lake. We have not done any trapping, and it would be interesting to know whether or not populations of *C. b. bartonii* and *C. acuminatus* have found congenial niches at greater depths or whether, as we believe, they have been totally replaced by *O. juvenilis*.

The presence of *O. juvenilis* in New River is possibly due to very recent migrations upstream from West Virginia. Had it been in this portion of the river for some years, it is likely that with all of the collecting that has been done in the river in the Mountain Lake area, it would have been encountered by one of us. While natural migration might furnish an entirely plausible explanation for its occurrence here, the fact that the two specimens came from near a fishing camp does not strengthen the possibility.

Throughout the range of the species, first form males have been collected in January and from April through November. Females with eggs were found only in April.

Although three ostracods and two branchiobdellids are associated with *O. juvenilis* at station 7, it seems unlikely that any of them reached this area on this crayfish. It seems more probable that the infestations occurred after the introduction of the crayfish.

The Ostracods

It is necessary in most instances to rely on the structure of the copulatory complex of the male for the identification of entocytherids, and this cannot be satisfactorily done unless the specimen has been cleared (temporary mounts in glycerine or permanent mounts in balsam or some comparable medium).³ The copulatory complex consists of a pair of modified appendages that during amplexus are so arranged that the clasping apparatus (fig. 7a) of each is directed anteriorly but which at most other times are rotated 180° with the clasping apparatus directed posteriorly. Orientation in descriptions is that of the clasping position. Figure 7a represents a composite copulatory complex that includes all of the secondary sexual characters utilized in the following key.

Whereas in the crayfishes it is the male that is dimorphic, in the entocytherids the female exists in two "forms": (1) the copulatory or biunguis female, which, to our knowledge, is the form that is always the partner in amplexing pairs (and perhaps should be considered the last "larval instar") and may be recognized by the 4-seg-

³ Most of our specimens have been prepared by dehydrating them with glacial acetic acid—transferring the specimen from formalin, water, or alcohol directly to the acid—clearing them in methyl salicylate and mounting them in balsam.

mented second antenna bearing only two terminal claws; (2) the gravid or triunguis female, which frequently contains eggs and may be recognized by the apparently 5-segmented antenna bearing three terminal claws.

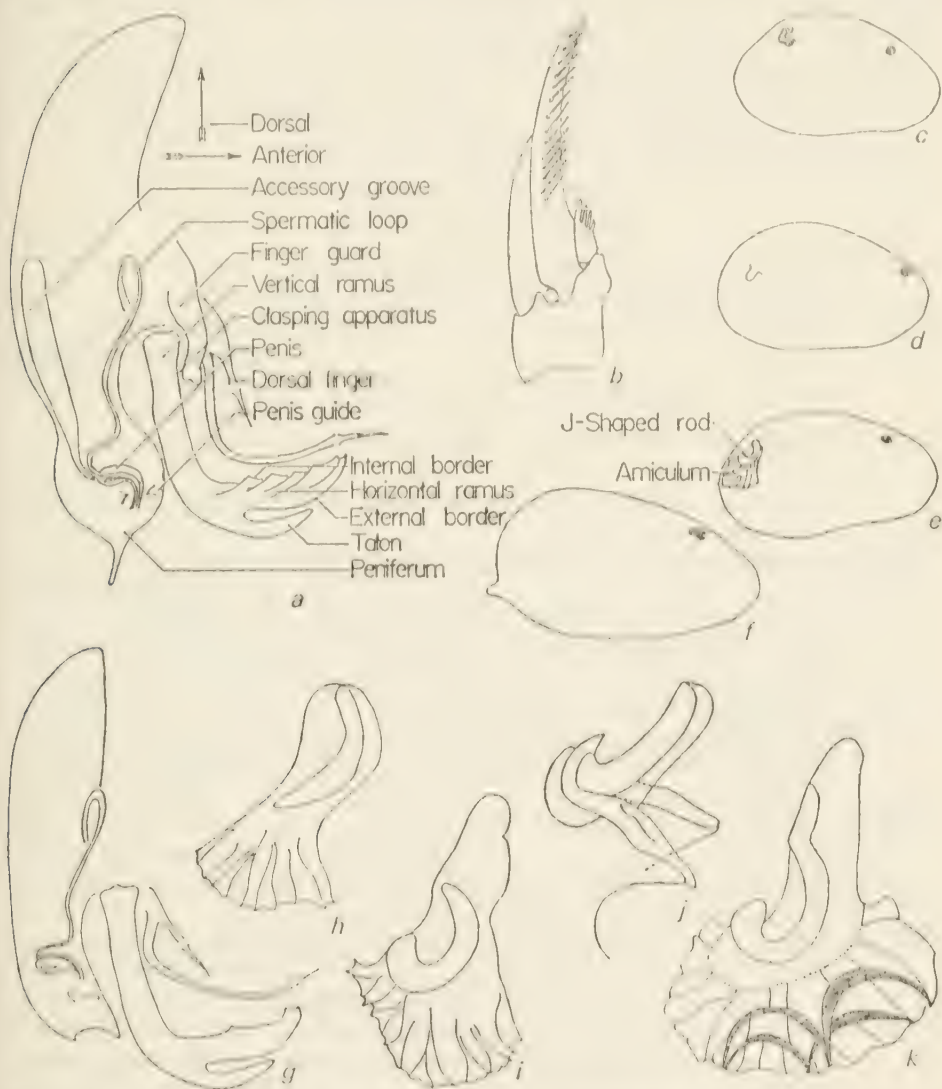


FIGURE 7.—Entocytherids: *a*, generalized peniferum illustrating structures mentioned in key; *b*, terminal claws of antenna of female *Entocythere internotalus*. Lateral views of shells: *c*, female *Asctocythere asceta*; *d*, female *Donnalsoncythere scalis*; *e*, female *Dactylocythere chalaza*; *f*, male *Dt. daphnioides*. Peniferum: *g*, *Ankylocythere ancyla*. Amicula and J-shaped rods: *h*, *Dt. suteri*; *i*, *Dt. chalaza*; *j*, *Dt. falcata*; *k*, *Dt. daphnioides*.

Unfortunately, few female entocytherids can be identified unless they are found in amplexus or can definitely be associated with the male. Few generic determinations of females are possible; however,

in the Mountain Lake region, the triunguis females of the four species of the genus *Dactylocythere* may be recognized by the presence of an amiculum (figs. 7e, h-k) and the posteroventral projection on the shell of *Dt. daphnioides* (fig. 7f), *Donnaldsoncythere* by the small corneous tubercles in the posterodorsal portion of the body, *Ascetocythere* by the small rounded prominence partially surrounded by an amorphous mass of refractile material in a corresponding position (fig. 7c), and *Entocythere* by the pectinate projection at the base of the terminal claws of the second antenna (fig. 7b).

Key to Male Ostracods

- | | | |
|-------|--|------------------------------|
| 1 | Copulatory complex provided with finger guard | 2 |
| 1' | Copulatory complex lacking finger guard | 6 |
| 2(1) | Peniferum without accessory groove; peniferum bulbiform distally. | |
| | Phymocythere phyma | |
| 2' | Peniferum with accessory groove; peniferum variable but never bulbiform. | |
| | Dactylocythere | 3 |
| 3(2') | Accessory groove extending distinctly dorsal to spermatic loop. | |
| | Dt. falcata | |
| 3' | Accessory groove extending approximately to dorsal level of spermatic loop | 4 |
| 4(3) | Posteroventral margin of shell with conspicuous prominence. | |
| | Dt. daphnioides | |
| 4' | Posteroventral margin of shell without conspicuous prominence | 5 |
| 5(4') | Junction of horizontal and vertical rami of clasping apparatus conspicuously thickened, and horizontal ramus provided with prominent tooth near junction | Dt. chalaza |
| 5' | Junction of horizontal and vertical rami of clasping apparatus not conspicuously thickened and horizontal ramus not provided with prominent tooth near junction. | Dt. suteri |
| 6(1') | Distal portion of peniferum with prominent flange and finger-like projection | Ascetocythere asceta |
| 6' | Distal portion of peniferum never with prominent flange or finger-like projection | 7 |
| 7(6') | External border of horizontal ramus of clasping apparatus with long talon | Ankylocythere ancyla |
| 7' | External border of horizontal ramus of clasping apparatus entire | 8 |
| 8(7') | Horizontal and vertical rami of clasping apparatus distinct and forming right angle; internal border of horizontal ramus serrate along entire margin | Entocythere |
| 8' | Horizontal and vertical rami of clasping apparatus not distinct and joining in angle greater than right angle; internal border of horizontal ramus never with more than three teeth. | |
| | Donnaldsoncythere | 10 |
| 9(8') | Mesial surface of junction of horizontal and vertical rami of clasping apparatus thickened and armed with one or more teeth or ridges. | |
| | E. internotalus | |
| 9' | Mesial surface of junction of horizontal and vertical rami of clasping apparatus not thickened and without teeth or ridges. | |
| | E. kanawhaensis | |

10(8')	Distal extremity of peniferum acuminate	Dn. ardis
10'	Distal extremity of peniferum truncate, rounded, or scooplike	11
11(10')	Distal extremity of peniferum scooplike	Dn. scalis
11'	Distal extremity of peniferum truncate or rounded	12
12(11')	Distal extremity of peniferum truncate	Dn. truncata
12'	Distal extremity of peniferum rounded	Dn. ileata

Genus *Ankylocythere* Hart, 1962

DIAGNOSIS.—Copulatory complex without finger guard; extensions of two rami of clasping apparatus never forming angle greater than 90° and bearing one or more teeth or excrescences on both internal and external borders of horizontal ramus; peniferum without accessory groove, variable, sometimes cleft distally but never with bulbous terminal or subterminal enlargement. Females without J-shaped rod, amiculum, or other comparable structure; claws of second antenna simple.

Ankylocythere ancyla Crawford

FIGURE 7g

Ankylocythere ancyla Crawford, 1965, pp. 148-149, figs. 1-3, 6, 7.

DIAGNOSIS.—Horizontal ramus of clasping apparatus with single tooth on internal border proximal to midlength and talon arising from external border much proximal to tooth on internal border; talon extending distally subparallel to ramus with tip reaching level just distal to tooth; ramus terminating in two upturned teeth; distal extremity of peniferum directed ventrally and shallowly excavate.

RANGE.—From the Savannah River drainage in South Carolina to the Roanoke River drainage in Virginia.

SPECIMENS EXAMINED.—60 specimens in eight collections from the following stations: 88, 89, 92, and 93. All localities are in the North Fork of the Roanoke River drainage, at elevations of 439 to 475 m.

HOSTS AND ASSOCIATES.—*Cambarus acuminatus* and *C. l. longulus* were associated with this ostracod in all stations, and *C. b. bartonii* was also present at stations 89, 92, and 93.

In all stations *Dt. falcata* was present, and at stations 88 and 93 *An. ancyla* was also collected with *Dn. truncata* and at station 88 with *E. internotalis*.

Branchiobdellid associates include *A. koronaeus*, *C. branchiophila*, *C. philadelphica* at stations 88, 89, 92, 93; and *C. fallax* and *Xd. formosus* at 88, 89, and 92.

Genus *Ascetocythere* Hart, 1962

DIAGNOSIS.—Hobbs and Hart (1966, p. 37) stated:

Terminal tooth of mandible with cusps. Copulatory complex without finger guard; peniferum extending ventrally much beyond clasping apparatus, elongate,

comparatively slender, with subterminal bulbous enlargement bearing one (anterior) or several projections; penis complex consisting of separate dorsal spermatic and ventral prostatic elements; spermatic element always shorter than clasping apparatus; accessory groove lacking. Clasping apparatus well developed, not always clearly divisible into vertical and horizontal rami; external border of horizontal ramus entire, internal border with two, three, or no teeth along apical half, if present often grouped far distally with three apical denticles.

Ascetocythere asceta (Hobbs and Walton)

FIGURES 7c, 8a

Entocythere asceta Hobbs and Walton, 1962, pp. 43-44, figs. 1-4.

Ascetocythere asceta Hart, 1962, p. 128.

DIAGNOSIS.—Hobbs and Hart (1966, p. 39) stated:

Peniferum with three prominences extending from subterminal bulbous expansion—anterior process delicate, club-shaped, extending anteroventrally, from cephalic surface; ventral process large, finger-like, with distinct angular flange near its midlength, and directed ventrally; posterior process small, rounded, and situated at posterior base of ventral process; prominent penis guide (acute projection) lying between flange and anterior process; penis reaching surface anteriorly dorsal to flange. Vertical ramus of clasping apparatus less than $\frac{1}{3}$ of total length of apparatus; internal border of horizontal ramus with two teeth along distal third with distal tooth almost midway between proximal tooth and apex.

RANGE.—Known from crayfish burrows in the James and New river systems in Craig and Giles Counties, Va., and from Monroe County, W. Va.

SPECIMENS EXAMINED.—275 specimens in 12 collections from the following stations: 8, 22, 40, 41, and 127, at elevations of 585 to 1250 m.

HOST AND ASSOCIATES.—*Ascetocythere asceta* is apparently restricted to the single host *Cambarus carolinus*.

Ostracod associates include but one species, *Dt. chalaza*, with which it was found in all five localities.

Branchiobdellid associates include *B. illuminatus* at stations 40, 41, and 127; and *C. fallax* at 40.

Genus *Donnaldsoncythere* Rioja, 1942

DIAGNOSIS.—Copulatory complex without finger guard; clasping apparatus frequently not divisible into vertical and horizontal rami and angle formed by extensions of two always greater than 90°; external border of horizontal ramus (or distal half of apparatus) entire and internal border never with more than three teeth near distal end, distal extremity terminating in from 3 to 10 serrations or emarginations; peniferum lacking accessory groove; corneous penis curved at almost right angle near midlength with proximal extremity level, or almost level, with base of clasping apparatus. Length of

penis greater than half that of clasping apparatus. Female without J-shaped rod or aniculum but with small corneous tube directed ventrally or posteroventrally in corresponding position; claws of second antenna simple.

Donnaldsoncythere ardis Hobbs and Walton

FIGURE 8b

Donnaldsoncythere ardis Hobbs and Walton, 1963, pp. 364-368, figs. 6-9, 10, 26.

DIAGNOSIS.—Copulatory complex with peniferum terminating ventrally in conspicuously slender, pointed extension; clasping apparatus only slightly curved along shaft, not divisible into vertical



FIGURE 8.—Penifera of entocytherids: a, *Ascetocythere asceta*; b, *Donnaldsoncythere ardis*; c, *Dn. ileata*.

and horizontal rami, distal portion slightly enlarged and directed anteroventrally, internal border with two teeth and apical border with four serrations.

RANGE.—The James River drainage in Craig, Giles, and Montgomery Counties, Va.

SPECIMENS EXAMINED.—Approximately 175 specimens from 18 collections in the following stations: 10-13, 20, 21, 23, 25, 27, 30-33, 35, 37, 123, and 124, at elevations from 402 to 622 m.

HOSTS AND ASSOCIATES.—*Donnaldsoncythere ardis* was associated with *Cambarus l. longulus* in all stations; with *C. b. bartonii* at stations 10, 12, 21, 23, 25, 32, 35, 37, 123, 124; and with *C. acuminatus* at 20, 27, 30-33, and 35.

Ostracods with which it was associated include *Dn. ileata* at all stations except 13, 27, 30; *Dt. suteri* and *E. internotalus* at 30, 31, 35; *Dt. suteri* at 27, 33, 124; and *E. internotalus* at 23.

Branchiobdellid associates include *C. philadelphica* at stations 10, 12, 20, 21, 25, 27, 32, 33, 35, 37, 123, 124; *C. holostoma* at 10, 11, 13, 20, 21, 23, 25, 37; *Xg. instabilis* at 11-13, 21, 37, 123; *Xd. formosus* at 10, 21; *A. koronaeus* at 30; *B. illuminatus* and *C. branchiophila* at 20; *C. heterognatha* at 123; and *P. alcicornus* at 25.

***Donnaldsoncythere ileata* Hobbs and Walton**

FIGURE 8c

Donnaldsoncythere ileata Hobbs and Walton, 1963, pp. 364, 368, figs. 11-15, 23.

DIAGNOSIS.—Copulatory complex with peniferum terminating ventrally in rounded extension, with posterior thickened border; anterior border always rounded; clasping apparatus with proximal shaft portion almost straight and distal third directed at angle of 90° to 135° to shaft; internal border of distal fourth with two teeth and terminal margin with four or five serrations.

RANGE.—Tributaries of the James, New, and Roanoke Rivers in Craig, Giles, and Montgomery Counties, Va., and Monroe County, W. Va.

SPECIMENS EXAMINED.—Approximately 3000 specimens from 100 collections from the following stations: 3-12, 14-16, 18-26, 28, 29, 31-35, 37, 43-48, 50-52, 54-67, 69, 71-77, 79-81, 84, 86, 94-99, 102, 104-110, 113, 116, 117, 119, and 122-126, at elevations of 415 to 899 m.

HOSTS AND ASSOCIATES.—In one or more stations, it was associated with every species of crayfish in the area except *C. carolinus*. It was with *C. b. bartonii* at stations 3-10, 12, 14, 16, 19, 21-26, 28, 29, 32, 34, 35, 37, 44-48, 50-52, 54, 57, 59, 60, 63, 64, 66, 69, 71, 74, 76, 77, 94-99, 107, 108, 110, 113, 117, 119, 122-125; with *C. sciotoensis* at 3, 5, 15, 18, 19, 43, 44, 50, 54-59, 61-67, 72, 73, 75, 79-81, 84, 86, 95-97, 102, 104-109, 116, 126; with *C. l. longulus* at 6, 7, 9-12, 20-23, 25, 29, 31-35, 37, 123, 124; with *C. acuminatus* at 20, 29, 31-33, 35; and with *O. juvenilis* at 7.

Although in 52 stations *Dn. ileata* was the only ostracod present, it was found with *P. phyma* at stations 3, 5, 7, 24, 44, 64; with *E. internotalus* at 23, 31, 35; with *Dt. suteri* at 31, 33, 35, 124; with *Dt. daphnioides* at 72, 73, 75, 79-81, 116; with *Dn. ardis* 10-12, 20, 21, 23, 25, 31-33, 35, 37, 123, and 124; with *Dn. truncata* at 54-57, 69, 71, 94; with *Dn. scalis* at 7, 44; and with *E. kanawhaensis* at 44, and 126.

Branchiobdellid associates include all 12 species known from the

area. It was with *C. philadelphica* at stations 3, 5, 8, 9, 10, 12, 14, 16, 19–22, 24–26, 28, 29, 32–35, 37, 44–46, 48, 50–52, 54–56, 59, 60, 66, 69, 71, 74, 76, 77, 94, 98, 106–110, 113, 119, 122–125; with *C. heterog-natha* at 3–5, 24, 28, 34, 45, 48, 61, 63–67, 72, 79–81, 86, 97, 105, 106, 116, 122, 123, 125, 126; with *C. fallax* at 3, 5, 15, 18, 24, 43, 54–58, 61, 63, 65–67, 71, 72, 75, 79, 81, 86, 95–97, 126; with *P. alcicornus* at 3–5, 15, 18, 19, 24, 25, 43, 58, 61, 63–67, 72, 76, 79, 81, 86, 95, 97, 104, 105; with *C. branchiophila* at 15, 18, 20, 24, 29, 43, 55, 57, 58, 63, 65–67, 72, 73, 75, 79, 81, 86, 97, 104, 116, 126; with *Xg. instabilus* at 3–5, 7, 9, 11, 12, 21, 22, 24, 37, 44, 46, 54, 60, 61, 64, 86, 95, 97, 123; with *B. illuminatus* at 5, 16, 19, 20, 22, 34, 44, 45, 48, 51, 59, 76, 86, 97, 122, 125; with *C. ingens* at 5, 15, 18, 54, 58, 61, 64, 67, 72, 73, 75, 79–81, 86, 95, 97, 104, 116; with *A. koronaeus* at 14, 18, 19, 29, 52, 69, 71, 72, 77, 98, 110, 125; with *C. holostoma* at 7, 10, 11, 18–23, 25, 37; with *Xd. formosus* at 10, 21; and with *A. legaeus* at 81.

REMARKS.—Not only is *Dn. ileata* the most variable ostracod in the region, it is perhaps the most aggressive. In all instances in which it was found associated with other ostracods, it was the most abundant, and it occurred unaccompanied by other ostracods in a far greater number of instances than any of the other species.

***Donnaldsoncythere scalis* Hobbs and Walton**

FIGURES 7d, 9a

Donnaldsoncythere scalis Hobbs and Walton, 1963, pp. 364–366, figs. 1–5, 25.

DIAGNOSIS.—Copulatory complex with peniferum terminating ventrally in scooplike expansion; clasping apparatus forming gentle arc, not divisible into vertical and horizontal rami, internal border with two teeth and apical border with four serrations.

RANGE.—Apparently restricted in the Mountain Lake region to Little Stony Creek (New River drainage) and two tributaries to Johns Creek and Potts Creek (James River drainage) in Giles County, Va., and Monroe County, W. Va.; elsewhere in the Susquehanna River drainage system in Luzerne and Wyoming Counties, Pa., and in a tributary of Lake Cayuga, Cayuga County, N.Y.

SPECIMENS EXAMINED.—Approximately 325 specimens from 16 collections in the following stations: 1, 2, 7, 17, 38, 39, 44, 68, 82, 83, 100, 101, 103, 114, and 115, at elevations of 671 to 1219 m.

HOSTS AND ASSOCIATES.—*Donnaldsoncythere scalis* was associated with *Cambarus b. bartonii* at all stations, with *C. sciotensis* at 44, and with *O. juvenilis* at 7.

Except at stations 7, 38, 44, 82, 101, and 103, it had no ostracod associates; at these it was accompanied by *P. phyma*; *Dn. ileata* and *E. kanawhaensis* were also present at 44.

Branchiobdellid associates include *C. philadelphia* at stations 17, 39, 44, 68, 115; *C. holostoma* at 7; *B. illuminatus* at 17, 44, 68, 115; and *Xg. instabilis* at 44.

Donnaldsoncythere truncata Hobbs and Walton

FIGURE 9b

Donnaldsoncythere truncata Hobbs and Walton, 1963, pp. 364-366, 369, figs. 16-20, 24.

DIAGNOSIS.—Copulatory complex with peniferum terminating ventrally in broad short terminal extension with subangular distal corners; neither corner conspicuously thickened; clasp ing apparatus with proximal shaft portion only slightly curved and distal third directed at angle of about 90° to proximal third; internal border of

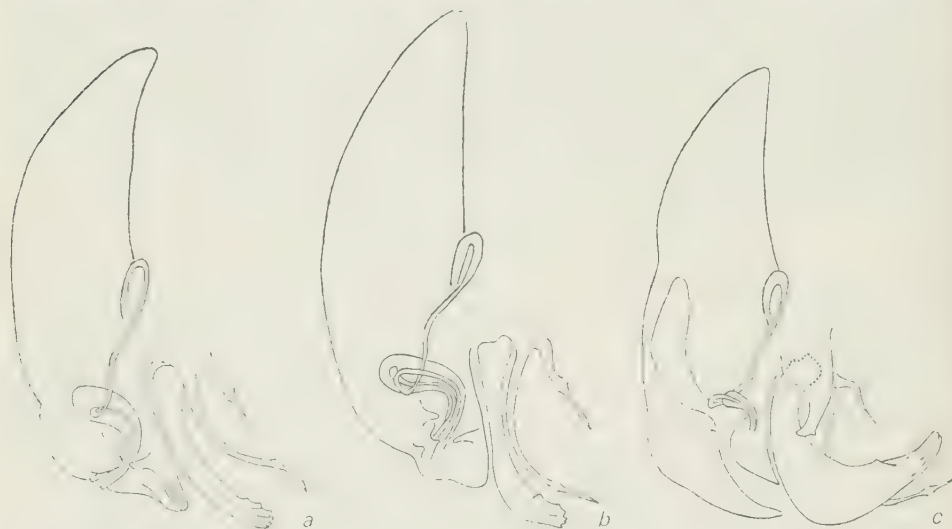


FIGURE 9.—Penifera of entocytherids: a, *Donnaldsoncythere scalis*; b, *Dn. truncata*; c, *Dactylocythere chalaza*.

distal fifth with six serrations, proximal three toothlike. Distal end of penis situated above terminal extension rather than posterodorsal to it as in other species of genus.

RANGE.—Tributaries of the New and Roanoke Rivers in Montgomery and Giles Counties, Va.

SPECIMENS EXAMINED.—Approximately 325 specimens from 17 collections from the following stations: 53-57, 69, 71, 87, 88, 90, 91, 93, 94, and 111. These are situated on tributaries to Walker Creek, Spruce Run, and Toms Creek (New River drainage) and from tributaries of the North Fork of the Roanoke River at elevations ranging from 445 to 625 m.

HOSTS AND ASSOCIATES.—In the Roanoke River drainage, *Dn. truncata* was associated with *Cambarus acuminatus* at stations 87, 88, 90, 91, 93; with *C. b. bartonii* at 87, 90, 91, 93, 111; and with *C. l. longulus* at 88, 90, 91, and 93. In the New River drainage, it was with *C. b. bartonii* and *C. sciotensis* at 54 and 57; with the former at 53, 69, 71, 94; and with *C. sciotensis* at 55 and 56.

Ostracod associates include *Dt. falcata* at stations 87, 88, 90, 91, 93, 111; *An. ancyla* at 88, 93; *E. internotalus* at 88, 90; *Dn. ileata* at 54–57, 69, 71, and 94. No ostracod associates were with it at 53.

Branchiobdellid associates include *C. philadelphica* at stations 53–56, 69, 71, 87, 88, 90, 91, 93, 94, 111; *A. koronaeus* at 69, 71, 87, 88, 90, 91, 93, 111; *C. branchiophila* at 55, 57, 87, 88, 90, 91, 93; *C. fallax* at 54–57, 71, 87, 88, 91; *Xd. formosus* at 88, 90, 91; *Xg. instabilis* at 53, 54; *B. illuminatus* at 87; and *C. ingens* at 54.

Genus *Dactylocythere* Hart, 1962

DIAGNOSIS.—Copulatory complex with finger guard; two rami of clasping apparatus never forming angle greater than 90° and usually (except in *Dt. striophylax* Crawford and *Dt. falcata* Hobbs and Walton) bearing teeth or serrations on internal border; peniferum provided with accessory sperm groove but never terminating in “barbed terminal extension” (Hart, 1962, p. 129). Females with J-shaped rod (except in *Dt. leptophylax* Crawford) and amiculum; claws of second antenna simple.

Dactylocythere chalaza (Hobbs and Walton)

FIGURES 7e, i, 9c

Entocythere chalaza Hobbs and Walton, 1962, p. 45, figs. 6–9.

Dactylocythere chalaza Hart, 1962, p. 129.

DIAGNOSIS.—Posteroventral margin of shell without conspicuous prominence. Accessory groove extending dorsally to level of spermathecal loop; clasping apparatus with junction of horizontal and vertical rami forming angle of less than 90° , distinctly thickened at junction, and internal border of horizontal ramus with single tooth and three distal serrations. Female with J-shaped rod and amiculum.

RANGE.—Drainage systems of the James and New Rivers in Craig and Giles Counties, Va., and Monroe County, W. Va.

SPECIMENS EXAMINED.—Approximately 775 specimens in 12 collections from the following stations: 8, 22, 40, 41, and 127, at elevations of 585 to 1250 m.

HOSTS AND ASSOCIATES.—*Dactylocythere chalaza*, like *As. asceta*, seems to be restricted to a single host *Cambarus carolinus*.

At each station *Dt. chalaza* was associated with *As. asceta*.

Branchiobdellid associates include *B. illuminatus* at stations 40, 41, 127; and *C. fallax* at 40.

***Dactylocythere daphnioides* (Hobbs)**

FIGURES 7f, k, 10a

Entocythere daphnioides Hobbs, 1955, p. 325, figs. 1, 2, 5-9.

Dactylocythere daphnioides Hart, 1962, p. 130.

DIAGNOSIS.—Posteroventral margin of shell with conspicuous prominence. Accessory groove extending dorsally to level of spermatid loop; clasping apparatus with junction of horizontal and vertical rami forming angle less than 90°, somewhat thickened at junction, and internal border of horizontal ramus with proximal tooth and four or five distal serrations. Female with J-shaped rod and amiculum.

RANGE.—From the Watauga drainage system in Avery and Watauga Counties, N.C.; the New River system from Alleghany and Ashe Counties, N.C., to Pocahontas County, W. Va.; and the Pound drainage system in Dickerson County, Va.

SPECIMENS EXAMINED.—Approximately 100 specimens in eight collections from the following stations: 70, 72, 73, 75, 79-81, and 116. All localities are in the New River drainage in Walker, Mill, and Wolf Creeks at elevations of 488 to 561 m.

HOST AND ASSOCIATES.—In all stations listed *Dt. daphnioides* was found on *Cambarus sciotoensis*.

Donnaldsonocythere ileata was the only ostracod associate and was present in all stations except 70.

Branchiobdellid associates include *C. ingens* at all stations; *P. alvicornus* at 70, 72, 73, 75, 79, 81; *C. fallax* at 70, 72, 75, 79, 81; *C. branchiophila* at 72, 73, 75, 79, 81, 116; *C. heterognatha* at 70, 72, 79-81, 116; *A. koronaeus* at 72; and *A. legaeus* at 81.

***Dactylocythere falcata* (Hobbs and Walton)**

FIGURES 7j, 10b

Entocythere falcata Hobbs and Walton, 1961, p. 379, figs. 2, 3, 7, 8.

Dactylocythere falcata Hart, 1962, p. 130.

DIAGNOSIS.—Posteroventral margin of shell without conspicuous prominence. Accessory groove extending dorsally beyond spermatid loop; clasping apparatus scythelike usually without teeth or serrations along internal border of horizontal ramus, although some specimens with single tooth near midlength. Female with J-shaped rod and amiculum.

RANGE.—The Hiwassee drainage system in North Carolina, Georgia, and Tennessee (Hobbs and Walton, 1961, p. 381) and from the Roanoke River and its tributaries in Montgomery County, Va.

SPECIMENS EXAMINED.—Approximately 90 specimens in 14 collections from the following stations: 85, 87–93, 111, and 112, at elevations of 439 to 597 m.

HOSTS AND ASSOCIATES.—*Dactylocythere falcata* was associated with *Cambarus l. longulus* and *C. acuminatus* at stations 88, 112; with *C. b. bartonii* at 85, 111; with *C. acuminatus* and *C. b. bartonii* at 87; and with the three at 89–93.

Entocytherid associates include *Dn. truncata* at stations 87, 88, 90, 91, 93, 111; *An. ancyla* at 88, 89, 92, 93; and *E. internotatus* at 88 and 90.

Branchiobdellid associates include *A. koronaeus*, which was present at all stations except 85, where no branchiobdellids were found; *C. branchiophila* at all except 85 and 111; *C. philadelphica* at all except 85; *C. fallax* at 87–89, 91, 92; *Xd. formosus* at 88–92, 112; and *B. illuminatus* at 87.

***Dactylocythere suteri* (Crawford)**

FIGURES 7h, 10c

Entocythere suteri Crawford, 1959, p. 162, pl. 3.

Dactylocythere suteri Hart, 1962, p. 131.

DIAGNOSIS.—Posteroventral margin of shell without conspicuous prominence. Accessory groove extending dorsally to level of sper-



FIGURE 10.—Penifera of entocytherids: a, *Dactylocythere daphnioides*; b, *Dt. falcata*; c, *Dt. suteri*.

matic loop; clasping apparatus with junction of horizontal and vertical rami rounded but extensions forming angle of less than 90°, with no thickening at junction, and internal border of horizontal ramus without proximal tooth but with series of five distal serrations. Female with J-shaped rod and amiculum.

RANGE.—Previously recorded from the drainage systems of the Wateree and Congaree Rivers in Richland County, S.C. (Crawford, 1959, p. 166); in the Mountain Lake region in tributaries of the James River in Craig County, Va.

SPECIMENS EXAMINED.—30 specimens in six collections from the following stations: 27, 30, 31, 33, 35, and 124 in Craig and Johns Creeks, at elevations of 402 to 482 m.

HOSTS AND ASSOCIATES.—In all stations it was associated with *Cambarus l. longulus* and *C. acuminatus* except at 124; and in 35 and 124 with *C. b. bartonii*.

Entocytherid associates include *Dn. ileata*, *Dn. ardis*, and *E. internotalus* at stations 31, 35; *Dn. ardis* and *E. internotalus* at 30; *Dn. ardis* and *Dn. ileata* at 33, 124; and *Dn. ardis* at 27.

Branchiobdellid associates include *C. philadelphica* at stations 27, 33, 35, 124; and *A. koronaeus* at 30.

Genus *Entocythere* Marshall, 1903

DIAGNOSIS.—Copulatory complex without finger guard; clasping apparatus extending ventrally beyond peniferum; extensions of two rami of clasping apparatus seldom (only in *E. dorsorotunda* Hoff, 1944) forming angle greater than 90°; external border of clasping apparatus entire and internal border serrate along entire length, tip terminating in three to five denticles; peniferum variable but usually irregularly rounded ventrally, and lacking accessory groove. Females without J-shaped rod, amiculum, or other comparable structure; second antenna with pectinate claw (fig. 7b).

Entocythere internotalus Crawford

FIGURES 7b, 11a

Entocythere internotalus Crawford, 1959, p. 152, pl. 1.

DIAGNOSIS.—Posterior surface of junction between horizontal and vertical rami of clasping apparatus rounded; internal border of horizontal ramus, including apex, with six teeth; mesial surface of proximal portion of horizontal ramus with one or two toothlike prominences.

RANGE.—Previously reported from many localities in the Congaree, Wateree, and Broad Rivers in Richland County, S.C. (Crawford,

1959, p. 156); in the Mountain Lake region present in tributaries of the James River in Craig County and in the North Fork of the Roanoke River, Montgomery County, Va.

SPECIMENS EXAMINED.—20 specimens in six collections from the following stations: 23, 30, 31, 35, 88, and 90 on tributaries of the James and Roanoke Rivers at elevations of 402 to 475 m.

HOSTS AND ASSOCIATES.—This ostracod was associated with *Cambarus acuminatus* and *C. l. longulus* at stations 30, 31, 35, 88; with *C. b. bartonii* and *C. l. longulus* at 23; and with the three at 35 and 90.

Ostracod associates include *An. ancyla* at station 88; *Dn. ardis* at 23, 30, 31, 35; *Dn. ileata* at 23, 31, 35; *Dt. falcata* and *Dn. truncata* at 88, 90; and *Dt. suteri* at 30, 31, and 35.

Branchiobdellid associates include *A. koronaeus* at stations 30, 88, 90; *C. branchiophila* at 88, 90; *C. philadelphia* at 35, 88, 90; *Xd. formosus* at 88, 90; *C. holostoma* at 23; and *C. fallax* at 88.

***Entocythere kanawhaensis* Hobbs and Walton**

FIGURE 11b

Entocythere kanawhaensis Hobbs and Walton, 1966b, Proc. U.S. Nat. Mus., vol. 119, no. 3542, p. 6, figs. 11-*o*.

DIAGNOSIS.—Posterior surface of junction between horizontal and vertical rami of clasping apparatus subangular; internal border of horizontal ramus, including apex, with nine teeth; mesial surface of horizontal ramus without teeth or emarginations.

RANGE.—Known only from the two localities cited below.

SPECIMENS EXAMINED.—4 specimens in two collections from station 44, Cascades on Little Stony Creek, and from the New River at Pembroke (sta. 126). Both stations are in the New River drainage in Giles County, Va., and are at altitudes of 500 and 899 m, respectively.

HOSTS AND ASSOCIATES.—Within the crayfish collection from station 44 were *C. b. bartonii* and *C. sciotoensis*; only the latter was present at 126.

Entocytherid associates include *P. phyma*, *Dn. ileata*, and *Dn. scalis* at station 44, and *Dn. ileata* at 126.

Branchiobdellid associates include *B. illuminatus*, *C. philadelphia*, and *Xg. instabilis* at station 44, and *C. branchiophila*, *C. fallax*, and *C. heterognatha* at 126.

Genus *Phymocythere* Hobbs and Hart, 1966

DIAGNOSIS.—Hobbs and Hart (1966, p. 48) stated:

Terminal tooth of mandible with cusps. Copulatory complex with finger guard; periferum extending ventrally much beyond clasping apparatus, elongate, comparatively slender, entirely corneous with terminal bulbous enlargement lacking

superficial extensions; penis complex consisting of separate dorsal spermathecal and ventral prostatic elements; spermathecal element longer than clasping apparatus; accessory groove lacking. Clasping apparatus reduced, not clearly divisible into vertical and horizontal rami; external border of horizontal ramus entire, internal border also entire except at apex, latter may be expanded and bear three to six denticles.

Phymocythere phyma (Hobbs and Walton)

FIGURE 11c

Entocythere phyma Hobbs and Walton, 1962, p. 44, figs. 10-13.

Cymocythere phyma Hart, 1962, p. 129.

Phymocythere phyma Hobbs and Hart, 1966, p. 48.

DIAGNOSIS.—Length of penis greater than longitudinal diameter of bulbiform portion of peniferum; clasping apparatus small and with distal margin not extending anterior to anterior margin of peniferum. Female unknown.



FIGURE 11.—Penifera of entocytherids: *a*, *Entocythere internotalus*; *b*, *E. kanawhaensis*; *c*, *Phymocythere phyma*.

RANGE.—Tributaries of the James, Potomac, New, and Tygart Rivers in Virginia and West Virginia. (See Hobbs and Hart, 1966, p. 48.)

SPECIMENS EXAMINED.—85 specimens in 12 collections from the following stations: 3, 5, 7, 24, 38, 44, 64, 82, 101, and 103. Represented are tributaries of Johns and Potts Creeks (James River drainage) and Big Stony and Little Stony Creeks (New River drainage), at elevations of 610 to 1143 m.

HOSTS AND ASSOCIATES.—*Phymocythere phyma* was associated with *Cambarus b. bartonii* at all stations; with *C. sciotoensis* at 3, 5, 44, 64; and *O. juvenilis* and *C. l. longulus* at 7.

Entocytherid associates include *Dn. ileata* at stations 3, 5, 7, 24, 44, 64; *Dn. scalis* at 7, 38, 44, 82, 101, 103; and *E. kanauchensis* at 44.

Branchiobdellid associates include *B. illuminatus* at stations 5, 44; *C. branchiophila* at 24; *C. heterognatha* and *P. alcornus* at 3, 5, 24, 64; *C. holostoma* at 7; *C. ingens* at 5, 64; *C. philadelphica* at 3, 5, 24, 44; and *Xg. instabilis* at 3, 5, 7, 24, 44, and 64.

The Branchiobdellids

The epizoites that compose the clitellate order Branchiobdellida are annelids with leechlike suckers and a short body of 15 segments of which the first four form a "head." Segmentation is obscured by coalescence in the head and also posteriorly in the formation of the posterior sucker, so that usually only the trunk segments are numbered; e.g., the anterior nephridia are said to open on segment III, but actually this is segment VII. The conventional system of designating the first trunk segment as I will be followed here. The body is cylindrical (terete) in most species, but members of three genera (*Ankyrodrilus*, *Xironodrilus*, and *Xironogiton*) are variously dorso-ventrally flattened (depressed) in body form.

The trunk segments, marked internally by distinct muscular septa anterior to the sucker, are further subdivided into annuli, normally only two, of which the anteriormost (prosome) is longer and often greater in diameter than the posterior annulus (metasome). Some branchiobdellids possess dorsal projections of various types on the prosomes of some trunk segments (fig. 20).

A prostomium, common among the annelids, is absent in the branchiobdellids. The mouth is surrounded by a peristomium (the first head segment) that is set off by a sulcus and may be entire (not divided into lobes or provided with tentacles) or variously lobed or tentaculate, but most often the peristomium forms dorsal and ventral lips. The buccal cavity of all branchiobdellids, presumably in the second head segment, is armed with sclerotized "jaws": one dorsal, one ventral. These jaws are usually provided with denticles ("teeth": figs. 12c, f). The number of teeth is often expressed by a "dental formula" in which the teeth of the upper jaw are enumerated first.

The reproductive systems have been found to provide the most reliable taxonomic characters. The components of these systems may best be understood by reference to figures 12b, 14a, and 15a. Testes, not patent in mature animals, are found in segments V and VI, ovaries in segment VII. Spermatogenic cells and spermatozoa fill the coelomic spaces of the testicular segments and the spermatozoa are conveyed to the outside by a series of ducts, beginning in the male funnels (f), which are the ental ends of the efferent ducts. The

effluent ducts (ed) unite in each testicular segment to form the deferent ducts (dd), which enter a glandular organ, the spermiducal gland (sg). The deferent ducts may enter the ental end of the spermiducal gland, with or without a previous thickening of the ducts, forming deferent lobes of the gland (dl), or they may enter the gland near its midlength. In some genera, an accessory gland, the prostate (pr), is given off as a blindly ending sac, at the ectal part of the spermiducal gland, where it narrows to form the muscular ejaculatory duct (ejd). The latter, in turn, joins the bursa (b), the muscular eversible sac (in the species considered here) enclosing the penis in its ental portion, which may be considerably elongated (as in *Ankyrodrilus*) or a short, pyriform organ (as in *Cambarincola*). Of these components of the male effluent apparatus, the spermiducal gland is always present but may vary in shape, in the presence or absence of deferent lobes and in the point of entry of the deferent ducts; the prostate may be present or absent and, if present, may be histologically similar to or different from the spermiducal gland and of varying proportional lengths and diameters; the ejaculatory duct may be either present or absent and of varying lengths, and the bursa of varying shapes. The other male parts exhibit little variation of taxonomic importance.

The female system is much simpler in arrangement and composition. There is little variation in the arrangement of the ovaries and ovipores in segment VII. The spermatheca (fig. 18) in segment V is an unpaired sac (but bifid in *Bdellodrilus*) that may vary from species to species in such features as the length and diameter of the ectal spermathecal duct, the diameter and length of the spermatozoa-storing spermathecal bulb, and the presence or absence of an ental process.

Key to Branchiobdellids

- | | | |
|-------|---|--|
| 1 | Body terete | 2 |
| 1' | Body depressed, at least in part. | 9 |
| 2(1) | With bifurcate spermatheca; without prostate | <i>Bdellodrilus illuminatus</i> |
| 2' | Spermatheca not bifurcate; prostate present | 3 |
| 3(2') | Trunk segments III, IV, V, and VIII with fanlike dorsal projections. | |
| | | <i>Pterodrilus alcornus</i> |
| 3' | Trunk segments without dorsal projections | 4 |
| 4(3') | Jaws similar in size and shape, both upper and lower jaws with odd number of teeth | 5 |
| 4' | Jaws dissimilar in at least shape, upper jaw with odd number, lower jaw with even number of teeth | 7 |
| 5(4) | With peristomial tentacles, dental formula 5/5 | <i>C. fallax</i> |
| 5' | Without peristomial tentacles, dental formula may or may not be 5/5 | 6 |
| 6(5') | Prostate histologically similar to spermiducal gland, spermiducal gland with deferent lobes, dental formula 5/5 | <i>C. branchiophila</i> |
| 6' | Prostate and spermiducal gland histologically dissimilar; dental formula often 3/3 | <i>C. holostoma</i> |

7(4')	Jaws grossly unequal in size	<i>C. heterognatha</i>
7'	Jaws similar in size	8
8(7')	Prostate longer than slender spermiducal gland	<i>C. ingens</i>
8'	Prostate shorter and lesser in diameter than spermiducal gland.	
		<i>C. philadelphica</i>
9(1')	Anterior body segments terete, fifth through eleventh segments depressed (tennis racquet shaped)	<i>Xironogiton instabilus</i>
9'	Body uniformly depressed, spatulate	10
10(9')	Deferent ducts enter ental end of spermiducal gland.	
		<i>Xironodrilus formosus</i>
10'	Deferent ducts enter midlength of T-shaped spermiducal gland.	
		<i>Ankyrodrilus</i> . . 11
11(10')	Dental formula $3/4$	<i>A. koronaeus</i>
11'	Dental formula $5/4$ or $5/5$	<i>A. legaeus</i>

Genus *Ankyrodrilus* Holt, 1965

DIAGNOSIS.—Holt (1965, p. 10) stated:

Branchiobdellid worms with two pairs of testes; paired nephridiopores on the dorsum of segment III; at least nine distinct segments visible in dorsal view; gut straight, with sacculations in segments II, III, IV, those of segments III and IV the larger; aggregations of gland cells present in lateral portions of segments VIII and IX; caudal sucker ventral; body depressed and tapering gradually from anterior end to its greatest width in segment VI, VII or VIII; spermiducal gland large with blindly ending bifurcated proximal portion, vasa deferentia entering the median portion of the organ; bursa constricted between atrial and penial sheath portions, giving the organ as a whole a reduplicated aspect; ejaculatory duct absent; spermatheca composed of ectal duct, bulb and ental process.

Ankyrodrilus koronaeus Holt

FIGURES 12a-d

Ankyrodrilus koronaeus Holt, 1965, p. 11.

DIAGNOSIS.—“Upper jaw with three large teeth, subequal in length; lower jaw convex, rounded at tooth-bearing border, carrying four small, subequal teeth” (Holt, 1965, p. 11).

RANGE.—Tributaries of the Roanoke, James, and New Rivers in Montgomery, Giles, Craig, and Botetourt Counties, Va.

SPECIMENS EXAMINED.—More than 160 specimens in 22 collections from the following stations: 14, 18, 19, 29, 30, 52, 69, 71, 72, 77, 87–93, 98, 110–112, and 125. These are in all the major drainages of the area at elevations ranging from 402 to 750 m.

HOST AND ASSOCIATES.—*A. koronaeus* was associated with *Cambarus acuminatus* at stations 29, 30, 87–93, 112; with *C. b. bartonii* at all stations except 18, 30, 72, 88, 112; with *C. l. longulus* at 29, 30, 88–93, 112; and with *C. sciotoensis* at 18, 19, and 72.

Ostracod associates include *An. ancyla* at stations 88, 89, 92, 93; *Dn. ileata* at 14, 18, 19, 29, 52, 69, 71, 72, 77, 98, 110, 125; *Dn. truncata*

at 69, 71, 87, 88, 90, 91, 93, 111; *Dt. daphnioides* at 72; *Dt. falcata* at 87-93, 111, 112; *Dn. ardis* and *Dt. suteri* at 30; and *E. internotalus* at 30, 88, and 90.

Branchiobdellid associates include *B. illuminatus* at stations 19, 87, 125; *C. branchiophila* at 18, 29, 72, 87-93, 112; *C. fallax* at 18, 71, 72, 87-89, 91, 92; *C. heterognatha* at 72, 125; *C. holostoma* at 18, 19; *C. ingens* at 18, 72; *C. philadelphia* at all stations except 18, 30, 72; *P. alcicornus* at 18, 19, 72; and *Xd. formosus* at 88-92, and 112.

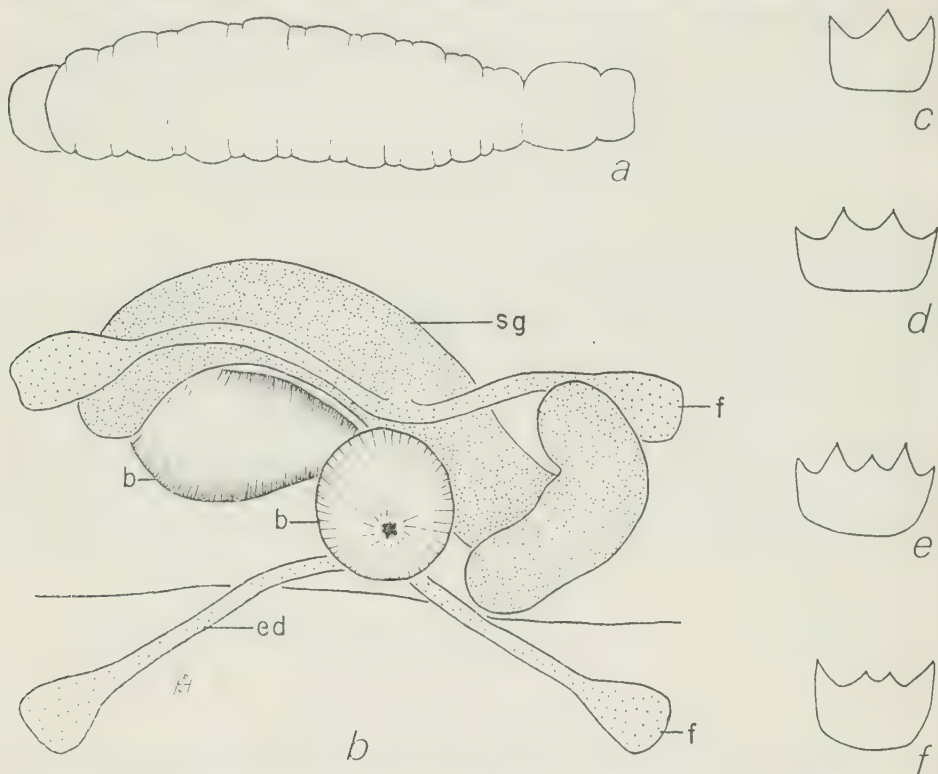


FIGURE 12.—*Ankyrodrilus koronaeus*: *a*, dorsal view; *b*, ventral view of male reproductive system; *c*, upper jaw; *d*, lower jaw. *A. legaeus*, jaws: *e*, upper; *f*, lower. (Abbreviations: *b*=bursa; *ed*=efferent duct; *f*=funnel; *sg*=spermiducal gland.)

REMARKS.—Present distribution records indicate that *A. koronaeus* and its congener, *A. legaeus*, are allopatric. Both species of *Ankyrodrilus* are inhabitants of middle altitude streams and may vicariate there for *Xg. instabilis* as inhabitants of the chelipeds of the host.

Ankyrodrilus legaeus Holt

FIGURES 12e-f

Ankyrodrilus legaeus Holt, 1965, p. 12.

DIAGNOSIS.—“Upper jaw with five teeth; lower jaw with four—five teeth; teeth of upper jaw of unequal length, lateral teeth and median

teeth shorter than others; lateral teeth of lower jaw longer than median teeth" (Holt, 1965, p. 12).

RANGE.—From Overton County, Tenn., sporadically to the New River drainage in Giles County, Va.

SPECIMENS EXAMINED.—7 specimens from station 81 in the New River drainage at an elevation of 488 m.

HOST AND ASSOCIATES.—*Ankyrodrilus legaeus* was associated with *Cambarus sciotensis* at station 81.

Ostracod associates include *Dn. ileata* and *Dt. daphnioides*.

Branchiobdellid associates include *C. branchiophila*, *C. fallax*, *C. heterognatha*, *C. ingens*, and *P. alcicornus*.

REMARKS.—*Ankyrodrilus legaeus* has been found associated with eight other species or subspecies of crayfishes; its single occurrence on *C. sciotensis* in the Mountain Lake region is no indication of host specificity.

Genus *Bdellodrilus* Moore, 1895

DIAGNOSIS.—Head elongated and less in diameter than anterior body segments; peristomium without lobes, body wall thin and glandular (parasitic facies); posterior sucker small and weak; two pairs of testes, no prostate, penis eversible; spermatheca bifid; lateral glands present in trunk segments I through IX; anterior nephridia open by common pore; upper jaw longitudinal ridge bearing three teeth, lower jaw deep trough in which dorsal one fits; inhabitants of gill chambers. Monotypic.

Bdellodrilus illuminatus (Moore)

FIGURES 13a-b

Branchiobdella illuminata Moore, 1894, p. 421.

Bdellodrilus illuminatus Moore, 1895b, p. 498.

DIAGNOSIS.—As above for the genus.

RANGE.—Eastern North America.

SPECIMENS EXAMINED.—Approximately 50 specimens in 24 collections from the following stations: 5, 16, 17, 19, 20, 22, 34, 40, 41, 44, 45, 48, 51, 59, 68, 76, 86, 87, 97, 115, 120-122, 125, and 127. All of the major drainage areas are represented among these stations. Elevations range from 518 to 1250 meters.

HOSTS AND ASSOCIATES.—*Bdellodrilus illuminatus* was associated with *Cambarus acuminatus* at stations 20, 87; with *C. b. bartonii* at all stations except 20, 40, 41, 86, 127; with *C. carolinus* at 22, 40, 41, 127; with *C. l. longulus* at 20, 22, 34; and with *C. sciotensis* at 5, 19, 44, 59, 86, and 97.

Ostracod associates include *As. asceta* and *Dt. chalaza* at stations 22, 40, 41, 127; *Dn. ardis* at 20; *Dn. ileata* at 5, 16, 19, 20, 22, 34, 44,

45, 48, 51, 59, 76, 86, 97, 122, 125; *Dn. scalis* at 17, 44, 68, 115; *Dn. truncata* and *Dt. falcata* at 87; *E. kanawhaensis* at 44; and *P. phyma* at 5 and 44.

Branchiobdellid associates include *A. koronaeus* at stations 19, 87, 125; *C. branchiophila* at 20, 86, 87, 97; *C. fallax* at 5, 40, 86, 87, 97; *C. heterognatha* at 5, 34, 45, 48, 86, 97, 122, 125; *C. holostoma* at 19, 20, 22; *C. ingens* at 5, 86, 97; *C. philadelphica* at all stations except 40, 41, 86, 97, 127; *P. alcornus* at 5, 19, 76, 86, 97; and *Xg. instabilis* at 5, 22, 44, 86, 97, and 121.

REMARKS.—*Bdellodrilus illuminatus* is an indisputable gill-inhabiting species. Often it is the only branchiobdellid associate of the burrowing *C. carolinus*, the only crayfish species with which it was found to occur more often than would be expected by chance.



FIGURE 13.—*Bdellodrilus illuminatus*, lateral views: *a*, entire animal; *b*, jaws.

Genus *Cambarincola* Ellis, 1912

DIAGNOSIS.—Body terete without specialized projections; anterior nephridia opening through common pore on dorsum of segment III; deferent ducts entering ental end of spermiducal gland; prostate and ejaculatory duct both present; penis noneversible; bursa subpyriform to obcordate; spermatheca never bifid.

Cambarincola branchiophila Holt

FIGURES 14a-c

Cambarincola branchiophila Holt, 1954, p. 168.

DIAGNOSIS.—Gill-inhabiting branchiobdellid; lips entire; dental formula 5/5, with lateralmost teeth longer than teeth between them

and median teeth; prosomites not raised; spermiducal gland with deferent lobes; prostate shorter than spermiducal gland and histologically similar; relatively large, stout (to about 3.5 mm in length).

RANGE.—Known only from the Mountain Lake area, *C. branchiophila* has been found in the major streams of all the drainage systems of the area.

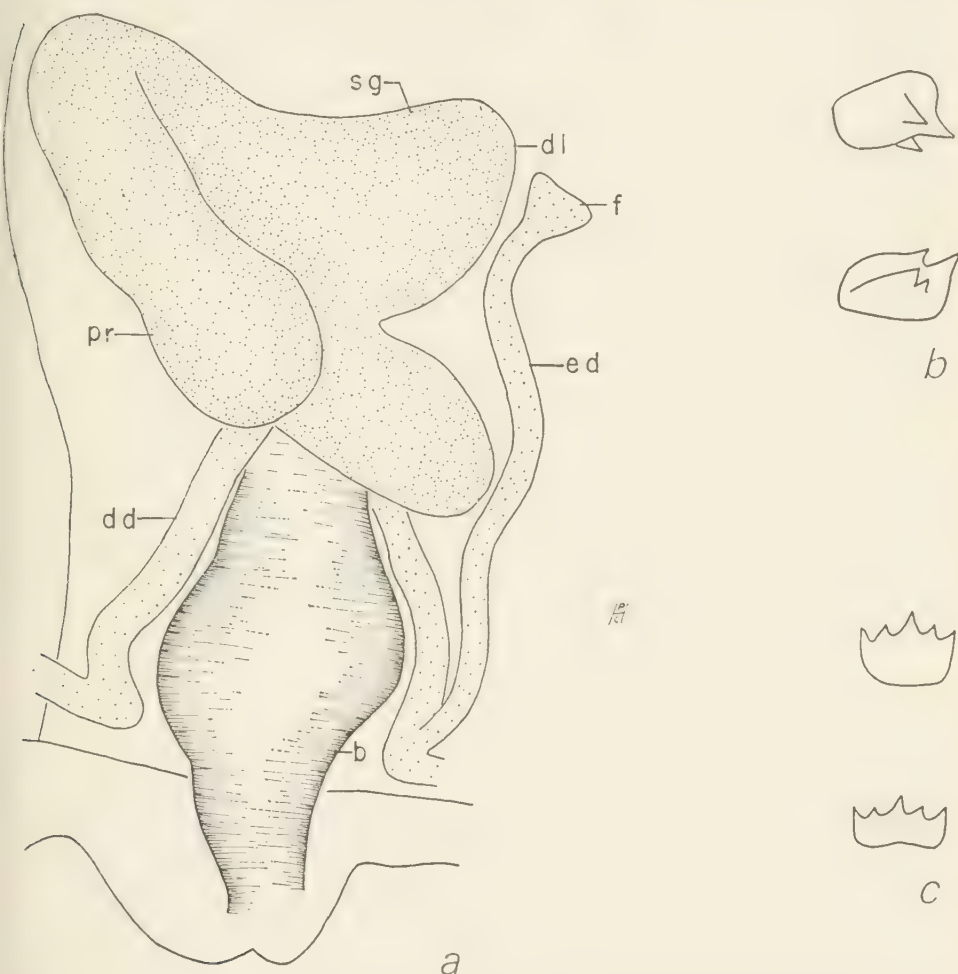


FIGURE 14.—*Cambarincola branchiophila*, lateral views: *a*, male reproductive system; *b*, jaws. En face view: *c*, jaws, upper uppermost. (Abbreviations: *b*=bursa; *dd*=deferent duct; *dl*=deferent lobe; *ed*=efferent duct; *f*=funnel; *pr*=prostate; *sg*=spermiducal gland.)

SPECIMENS EXAMINED.—More than 150 specimens in 31 collections from the following stations: 15, 18, 20, 24, 29, 43, 55, 57, 58, 63, 65–67, 72, 73, 75, 79, 81, 86–93, 97, 104, 112, 116, and 126. Elevations range from 427 to 762 m.

HOSTS AND ASSOCIATES.—*Cambarincola branchiophila* was associated with *Cambarus acuminatus* at stations 20, 29, 87–93, 112; with *C. b.*

bartonii at 24, 29, 57, 63, 66, 87, 89-93, 97; with *C. l. longulus* at 20, 29, 88-93, 112; and with *C. sciottensis* at all stations except 20, 24, 29, 87-93, 112.

Ostracod associates include *An. ancylla* at stations 88, 89, 92, 93, *Dn. ardis* at 20; *Dn. ileata* at all stations except 87-93, 112; *Dn. truncata* at 55, 57, 87, 88, 90, 91, 93; *Dt. daphnioides* at 72, 73, 75, 79, 81, 116; *Dt. falcata* at 87-93, 112; *E. internotulus* at 88, 90; *E. kanawhaensis* at 126; and *P. phyma* at 24.

Branchiobdellid associates include *A. koronaeus* at stations 18, 29, 72, 87-93, 112; *A. legaeus* at 81; *B. illuminatus* at 20, 86, 87, 97; *C. fallax* at all stations except 20, 29, 73, 90, 93, 104, 112, 116; *C. heterognatha* at 24, 63, 65-67, 72, 79, 81, 86, 97, 116, 126; *C. holostoma* at 18, 20; *C. ingens* at 15, 18, 58, 67, 72, 73, 75, 79, 81, 86, 97, 104, 116; *C. philadelphia* at 20, 24, 29, 55, 66, 87-93, 112; *P. alvicornus* at 15, 18, 24, 43, 58, 63, 65-67, 72, 73, 75, 79, 81, 86, 97, 104; *Xd. formosus* at 88-92, 112; and *Xg. instabilis* at 24, 86, and 97.

REMARKS.—*Cambarincola branchiophila* does not exhibit the "parasitic facies" to the extreme extent that *B. illuminatus* does. Two explanations of the association of these species are possible: *C. branchiophila* may be incompletely adapted to the gill chamber habitat and is occasionally found outside the gill chambers, or, more likely, the association is due to the occurrence of these two species on separate individuals of the host from the same collection.

Cambarincola fallax Hoffman

FIGURES 15a-b

Cambarincola fallax Hoffman, 1963, p. 356.

DIAGNOSIS.—Upper lip with short, slender peristomial tentacles; prosomites raised; dental formula 5/5, jaws of same size and shape; prostate with terminal bulb and histologically dissimilar to spermiducal gland.

RANGE.—From northern New York to northern Georgia in the mountains and piedmont.

SPECIMENS EXAMINED.—More than 300 specimens in 35 collections from the following stations: 3, 5, 15, 18, 24, 40, 43, 49, 54-58, 61, 63, 65-67, 70-72, 75, 78, 79, 81, 86-89, 91, 92, 95-97, and 126 at elevations from 439 to 1158 m. This species, common to the three drainage systems of the area, appears to be somewhat less common in the James than in the others: it was taken twice (sta. 11 and 24) from Johns Creek.

HOSTS AND ASSOCIATES.—*Cambarincola fallax* was associated with *Cambarus acuminatus* at stations 87-89, 91, 92; with *C. b. bartonii* at 3, 5, 24, 49, 54, 57, 63, 66, 71, 87, 89, 91, 92, 95-97; with *C. carolinus*

at 40; with *C. l. longulus* at 88, 89, 91, 92; with *C. sciotoensis* at 3, 5, 15, 18, 43, 54-58, 61, 63, 65-67, 70, 72, 75, 78, 79, 81, 86, 95-97, and 126.

Ostracod associates include *An. ancyla* at stations 88, 89, 92; *As. acuta* at 40; *Dn. ileata* at 3, 5, 15, 18, 24, 43, 54-58, 61, 63, 65-67, 71, 72, 75, 79, 81, 86, 95-97, 126; *Dn. truncata* at 54-57, 71, 87, 88, 91; *Dt. chalaza* at 40; *Dt. daphnioides* at 70, 72, 75, 79, 81; *Dt. fulcata* at 87-89, 91, 92; *E. internotatus* at 88; *E. kanawensis* at 126; and *P. phyma* at 3, 5, and 24.

Branchiobdellid associates include *A. koronatus* at stations 18, 71, 72, 87-89, 91, 92; *A. lycaeus* at 81; *B. illuminatus* at 5, 40, 80, 87, 97; *C. branchiophila* at 15, 18, 24, 43, 55, 57, 58, 63, 65-67, 72, 75, 79, 81, 86-89, 91, 92, 97, 126; *C. heterognatha* at 3, 5, 24, 61, 63, 65-67; 70, 72, 78, 79, 81, 86, 97, 126; *C. holostoma* at 18; *C. ingens* at 5, 15,



FIGURE 15.—*Cambarincola fallax*: a, lateral view of entire animal; b, en face view of jaws.

18, 54, 58, 61, 67, 70, 72, 75, 79, 81, 86, 95, 97; *C. philabryphica* at 3, 5, 24, 54-56, 66, 71, 87-89, 91, 92; *P. alcornus* at 3, 5, 15, 18, 24, 43, 58, 61, 63, 65-67, 70, 72, 75, 79, 81, 86, 95, 97; *Xd. formosus* at 88, 89, 91, 92; and *Xg. instabilis* at 3, 5, 24, 54, 61, 86, 95, and 97.

Cambarincola heterognatha Hoffman

FIGURES 16a-c

Cambarincola heterognatha Hoffman, 1963, p. 362.

DIAGNOSIS.—Without peristomial tentacles; prosomites not distinctly raised; dental formula 1/4 (usually), upper jaw strikingly larger than lower; prostate half or less length of spermiducal gland and dissimilar histologically.

RANGE.—In the mountainous regions of West Virginia, Virginia, North Carolina, Tennessee, and Kentucky (Adair County).

SPECIMENS EXAMINED.—Approximately 100 specimens in 28 collections from the following stations: 3, 4, 5, 24, 28, 34, 45, 48, 61, 63–67, 70, 72, 78–81, 86, 97, 105, 106, 116, 122, 123, 125, and 126. These stations are in the New and James river systems at elevations from 451 to 838 m.

HOSTS AND ASSOCIATES.—*Cambarincola heterognatha* was associated with *Cambarus b. bartonii* at stations 3–5, 24, 28, 34, 45, 48, 63, 64, 66,

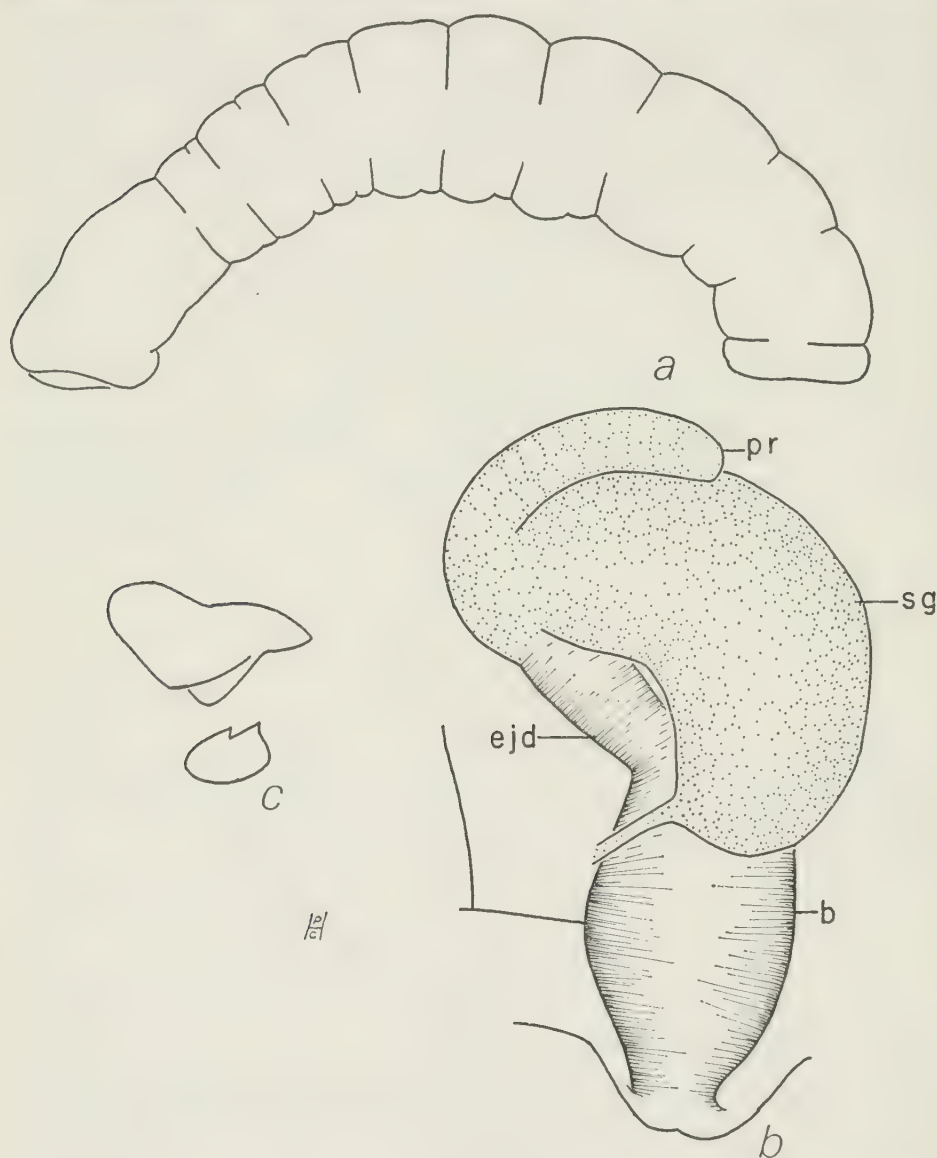


FIGURE 16.—*Cambarincola heterognatha*, lateral views: *a*, entire animal; *b*, male reproductive system; *c*, jaws. (Abbreviations: *b*=bursa; *ejd*=ejaculatory duct; *pr*=prostate; *sg*=spermiducal gland.)

97, 122, 123, 125; with *C. l. longulus* at 34, 123; with *C. sciotensis* at 3, 5, 61, 63–67, 70, 72, 78–81, 86, 97, 105, 106, 116, and 126.

Ostracod associates include *Dn. ardis* at station 123; *Dn. ileata* at all stations except 70 and 78; *Dt. daphnioides* at 70, 72, 79–81, 116; *E. kanawhaensis* at 126; and *P. phyma* at 3, 5, 24, and 64.

Branchiobdellid associates include *A. koronaeus* at stations 72, 125; *A. legaeus* at 81; *B. illuminatus* at 5, 34, 45, 48, 86, 97, 122, 125; *C. branchiophila* at 24, 63, 65–67, 72, 79, 81, 86, 97, 116, 126; *C. fallax* at 3, 5, 24, 61, 63, 65–67, 70, 72, 78, 79, 81, 86, 97, 126; *C. ingens* at 5, 61, 64, 67, 70, 72, 79–81, 86, 97, 116; *C. philadelphia* at 3, 5, 24, 28, 34, 45, 48, 66, 106, 122, 123, 125; *P. alcicornus* at 3–5, 24, 61, 63–67, 70, 72, 79, 81, 86, 97, 105; and *Xg. instabilis* at 3–5, 24, 61, 64, 86, 97, and 123.

REMARKS.—The absence of *C. heterognatha* in our collections from the Roanoke drainage is surprising; but the species, in our experience, is predominantly one of tributary streams of the mountains and most of our collections from the Roanoke were from regions of lower gradient and fair volume of stream flow. There exists (Hoffman, 1963, p. 364) a record of *C. heterognatha* from Franklin County, Va., which is within the Roanoke River system. Only a more detailed analysis of the distribution of the species will enable a decision to be made as to whether the species is just now, at some favorable areas of stream capture, invading the Roanoke or whether the distribution as known is determined by local stream conditions.

***Cambarincola holostoma* Hoffman**

FIGURES 17a–d

Cambarincola holostoma Hoffman, 1963, p. 359.

DIAGNOSIS.—Peristomium entire without lobes or tentacles; prosomites not of greater diameter than metasomites; dental formula 3/3; reproductive systems similar to those of *C. philadelphia*.

RANGE.—*Cambarincola holostoma* is known only from western Virginia in the headwaters of the Potomac and James Rivers with an isolated occurrence in Sinking Creek (sta. 18, 19) of the New River drainage.

SPECIMENS EXAMINED.—Approximately 80 specimens in 12 collections from the following stations: 7, 10, 11, 13, 18–23, 25, and 37. These stations are in the James River drainage (Potts, Johns, and Craig Creeks) except 18 and 19 which are in the New River drainage (Sinking Creek). The elevations of these stations range from 512 to 671 m.

HOSTS AND ASSOCIATES.—*Cambarincola holostoma* was associated with *Cambarus acuminatus* at station 20; with *C. b. bartonii* at 7, 10,

19, 21–23, 25, 37; with *C. carolinus* at 22; with *C. l. longulus* at 7, 10, 11, 13, 20–23, 25, 37; with *C. sciotoensis* at 18, 19; and with *O. juvenilis* at 7.

Ostracod associates include *As. asceta* and *Dt. chalaza* at station 22; *Dn. ardis* at 10, 11, 13, 20, 21, 23, 25, 37; *Dn. ileata* at 7, 10, 11, 18–23, 25, 37; *Dn. scalis* and *P. phyma* at 7; and *E. internotalus* at 23.

Branchiobdellid associates include *A. koronaeus* at stations 18, 19; *B. illuminatus* at 19, 20, 22; *C. branchiophila* at 18, 20; *C. fallax* and *C. ingens* at 18; *C. philadelphia* at 10, 19–22, 25, 37; *P. alcicornus* at 18, 19, 25; *Xd. formosus* at 10, 21; and *Xg. instabilis* at 7, 11, 13, 21, 22, and 37.

REMARKS.—*Cambarincola holostoma*, on the basis of present knowledge, appears to be a highly localized species that has recently invaded the headwaters of Sinking Creek from the nearby tributaries of the James River.

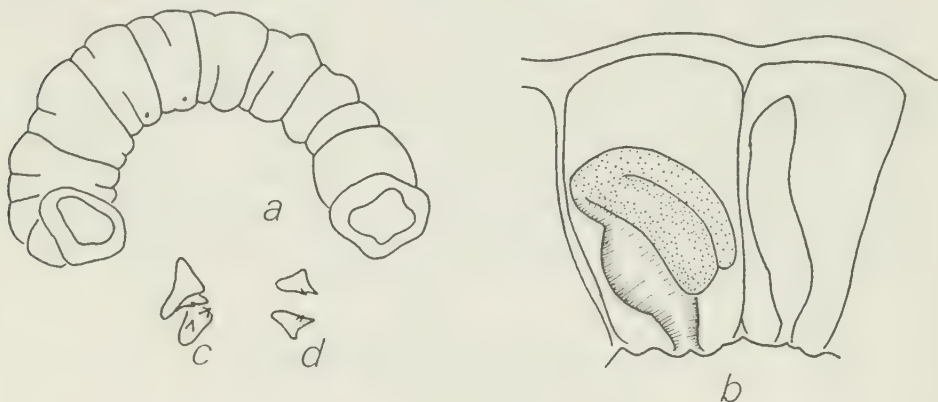


FIGURE 17.—*Cambarincola holostoma*: a, lateroventral view of entire animal; b, lateral view of male reproductive system and spermatheca; c, dorsolateral view of jaws; d, lateral view of jaws. (After Hoffman, 1963.)

Cambarincola ingens Hoffman

FIGURES 18a–d

Cambarincola ingens Hoffman, 1963, p. 333.

DIAGNOSIS.—Upper lip of peristomium with four long lobes or short tentacles; prosomites only moderately greater in diameter than metasomites; dental formula 5/4 or 3/4; prostate longer than spermiducal gland and bent back upon itself; large worms, to 6 mm after preservation.

RANGE.—Blue Ridge and Valley and Ridge physiographic provinces of the southern Appalachians, in the New and Tennessee river drainage systems of West Virginia, Virginia, North Carolina, and Tennessee and the Roanoke (Smith River) drainage in Patrick County, Va.

SPECIMENS EXAMINED.—Approximately 80 specimens in 20 collections from the following stations: 5, 15, 18, 54, 58, 61, 64, 67, 70, 72, 73, 75, 79–81, 86, 95, 97, 104, and 116. All of these stations are in the New River drainage at elevations from 488 to 777 m.

HOSTS AND ASSOCIATES.—*Cambarincola ingens* was associated with *Cambarus b. bartonii* at stations 5, 54, 64, 95, 97; and with *C. sciotensis* in all stations.

Ostracod associates include *Dn. ilcata* at all stations except 70; *Dn. truncata* at 54; *Dt. daphnioides* at 70, 72, 73, 75, 79–81, 116; and *P. phyma* at 5, and 64.

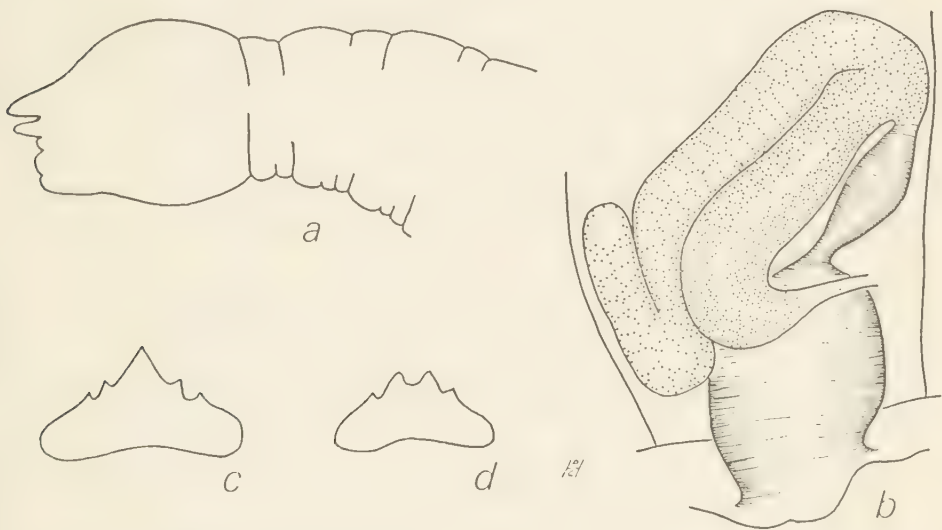


FIGURE 18.—*Cambarincola ingens*, lateral views: *a*, anterior portion of entire animal; *b*, male reproductive system. En face views: *c*, upper jaw; *d*, lower jaw.

Branchiobdellid associates include *A. koronaeus* at stations 18, 72; *A. legatus* at 81; *B. illuminatus* at 5, 86, 97; *C. branchiophila* at 15, 18, 58, 67, 72, 73, 75, 79, 81, 86, 97, 104, 116; *C. fallax* at 5, 15, 18, 54, 58, 61, 67, 70, 72, 75, 79, 81, 86, 95, 97; *C. heterognatha* at 5, 61, 64, 67, 70, 72, 79–81, 86, 97, 116; *C. holostoma* at 18; *C. philadelphica* at 5, 54; *P. alcicornus* at 5, 15, 18, 58, 61, 64, 67, 70, 72, 73, 75, 79, 81, 86, 95, 97, 104; and *Xg. instabilis* at 5, 54, 61, 64, 86, 95, and 97.

REMARKS.—On the basis of presently known distribution records, *C. ingens* is a native of the New River that has spread to only a few other drainage systems, notably the Tennessee. Our data positively associates *C. ingens* only with *Cambarus sciotensis* as a host, but it is known that other crayfishes serve as hosts for this branchiobdellid. (Hoffman, 1963, p. 336.)

Cambarincola philadelphica (Leidy)

FIGURES 19a-d

Astacobdella philadelphica Leidy, 1851, p. 209.*Branchiobdella philadelphica* Moore, 1894, p. 427.*Bdellodrilus philadelphicus* Moore, 1895b, p. 498.*Cambarincola philadelphica* Ellis, 1912, p. 485.

DIAGNOSIS.—Hoffman (1963, p. 346) stated:

Peristomium divided into dorsal and ventral lobes, the dorsal larger and with four low marginal lobations; jaws relatively large and subrectangular in lateral aspect, the dorsal jaw usually a little larger than the ventral [and the dental formula $5/4$ to $3/2$]; male reproductive system moderate in size, filling from half to two-thirds of the coelom of one side of segment VI; bursa elongate, at least twice as long as broad, the penial sheath merging gradually into a fairly short ejaculatory duct; spermiducal gland slender and recurved ventrad, twice the diameter of prostate, latter long and slender, reaching to ental end of spermiducal gland.

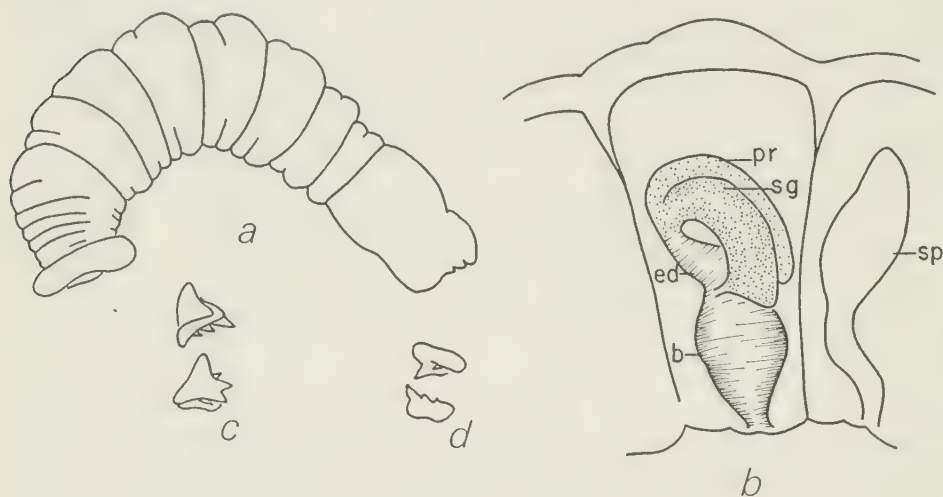


FIGURE 19.—*Cambarincola philadelphica*, lateral views: *a*, entire animal; *b*, male reproductive system and spermatheca; *d*, jaws. Dorsolateral view: *e*, jaws. (Abbreviations: *b*=bursa; *ed*=ejaculatory duct; *pr*=prostate; *sp*=spermatheca; *sg*=spermiducal gland. After Hoffman, 1963.)

RANGE.—Eastern North America, from southern Canada south to South Carolina and west to Wisconsin (Hoffman, 1963).

SPECIMENS EXAMINED.—More than 500 specimens in 72 collections from the following stations: 3, 5, 8–10, 12, 14, 16, 17, 19–22, 24–29, 32–37, 39, 44–46, 48, 50–56, 59, 60, 66, 68, 69, 71, 74, 76, 77, 87–94, 98, 106–113, 115, and 118–125. These specimens came from all drainage systems of the area and from elevations of 427 to 1170 m.

HOSTS AND ASSOCIATES.—*Cambarincola philadelphica* was associated with *Cambarus acuminatus* at stations 20, 27, 29, 32, 33, 35, 87–93, 112; with *C. b. bartonii* at all stations except 20, 27, 33, 55, 56, 88, 106, 109,

112; with *C. carolinus* at 8, 22; with *C. l. longulus* at 9, 10, 12, 20–22, 25, 27, 29, 32–35, 37, 88–93, 112, 123, 124; and with *C. sciotensis* at 3, 5, 19, 44, 50, 54–56, 59, 66, and 106–109.

Ostracod associates include *An. ancyra* at stations 88, 89, 92, 93; *As. assecta* and *Dt. chalaza* at 8, 22; *Dn. ardis* at 10, 12, 20, 21, 25, 27, 32, 33, 35, 37, 123, 124; *Dn. ileata* at all stations except 17, 27, 36, 39, 53, 68, 87–93, 111, 112, 115, 118, 120, 121; *Dn. scalis* at 17, 39, 44, 68, 115; *Dn. truncata* at 53–56, 69, 71, 87, 88, 90, 91, 93, 94, 111; *Dt. falcata* at 87–93, 111, 112; *Dt. suteri* at 27, 33, 35, 124; *E. internotatus* at 35, 88, 90; *E. kanawhaensis* at 44; and *P. phyma* at 3, 5, 24, and 44.

Branchiobdellid associates include *A. koronaeus* at stations 14, 19, 29, 52, 69, 71, 77, 87–93, 98, 110–112, 125; *B. illuminatus* at 5, 16, 17, 19, 20, 22, 34, 44, 45, 48, 51, 59, 68, 76, 87, 115, 120–122, 125; *C. branchiophila* at 20, 24, 29, 55, 66, 87–93, 112; *C. fallax* at 3, 5, 24, 54–56, 66, 71, 87–89, 91, 92; *C. heterognatha* at 3, 5, 24, 28, 34, 45, 48, 66, 106, 122, 123, 125; *C. holostoma* at 10, 19–22, 25, 37; *C. ingens* at 5, 54; *P. alcicornus* at 3, 5, 19, 24, 25, 66, 74, 76; *Xd. formosus* at 10, 21, 88–92, 112; and *Xg. instabilis* at 3, 5, 9, 12, 21, 22, 24, 37, 44, 46, 53, 54, 60, 121, and 123.

Genus *Pterodrilus* Moore, 1895

DIAGNOSIS.—Distinguished from *Cambarincola* by smaller size and presence of dorsal projections on prosomites of at least one trunk segment.

Pterodrilus alcicornus Moore

FIGURE 20

Pterodrilus alcicornus Moore, 1895a, p. 449.

DIAGNOSIS.—With fanlike and cylindrical processes on dorsum of prosomites of segments III, IV, v, VIII.

RANGE.—Southern Appalachians from Virginia southward to North Carolina and Tennessee (principally in the New and Tennessee Rivers).

SPECIMENS EXAMINED.—Approximately 125 specimens in 29 collections from the following stations: 3–5, 15, 18, 19, 24, 25, 43, 58, 61, 63–67, 70, 72–76, 79, 81, 86, 95, 97, 104, and 105. All but two of these stations are in the New River drainage; stations 24 and 25 are in the James (tributaries of Johns Creek) drainage. Elevations range from 488 to 838 m.

HOSTS AND ASSOCIATES.—*Pterodrilus alcicornus* was associated with *Cambarus b. bartonii* at stations 3–5, 19, 24, 25, 63, 64, 66, 74, 76, 95, 97; with *C. l. longulus* at 25; and with *C. sciotensis* at 3, 5, 15, 18, 19, 43, 58, 61, 63–67, 70, 72, 73, 75, 79, 81, 86, 95, 97, 104, and 105.

Ostracod associates include *Dn. ardis* at station 25; *Dn. ileata* at all stations except 70; *Dt. daphnioides* at 70, 72, 73, 75, 79, 81; and *P. phyma* at 3, 5, 24, and 64.

Branchiobdellid associates include *A. koronaeus* at stations 18, 19, 72; *A. legatus* at 81; *B. illuminatus* at 5, 19, 76, 86, 97; *C. branchiophila* at 15, 18, 24, 43, 58, 63, 65-67, 72, 73, 75, 79, 81, 86, 97, 104; *C. fallax* at 3, 5, 15, 18, 24, 43, 58, 61, 63, 65-67, 70, 72, 75, 79, 81, 86, 95, 97; *C. heterognatha* at 3-5, 24, 61, 63-67, 70, 72, 79, 81, 86, 97, 105; *C. holostoma* at 18, 19, 25; *C. ingens* at 5, 15, 18, 58, 61, 64, 67, 70, 72, 73, 75, 79, 81, 86, 95, 97, 104; *C. philadelphica* at 3, 5, 19, 24, 25, 66, 74, 76; and *Xg. instabilis* at 3-5, 24, 61, 64, 86, 95, and 97.



FIGURE 20.—*Pterodrilus alpicornus*, lateral view.

Genus *Xironodrilus* Ellis, 1918

DIAGNOSIS.—Body depressed, widening gradually from segment I to segment VII; deferent ducts entering ental end of spermiducal gland; prostate absent; bursa spherical.

Xironodrilus formosus Ellis

FIGURES 21a-d

Xironodrilus formosus Ellis, 1918, p. 49.

DIAGNOSIS.—Dental formula 4/3 to 6/5, teeth subequal in size with lateral teeth somewhat shorter than median ones; spermathecal duct distinct, bulb of spermatheca globose or cylindrical; spermiducal gland simple U-shaped tube, less than twice diameter of vasa deferentia; ejaculatory duct absent.

RANGE.—Michigan, Indiana, Kentucky, Virginia. The range of *Xl. formosus* appears to be discontinuous; it is present in the James and Roanoke Rivers but apparently absent in the New River.

SPECIMENS EXAMINED.—Approximately 30 specimens in 8 collections from the following stations: 10, 21, 88–92, and 112. Of these stations 10 and 21 are on Johns Creek at elevations of 549 and 561 m, and the remainder are on the Roanoke River and the lower reaches of its tributaries at elevations from 439 to 543 m.

HOSTS AND ASSOCIATES.—*Xironodrilus formosus* was associated with *Cambarus acuminatus* at stations 88–92, 112; with *C. b. bartonii* at 10, 21, 89–92; and with *C. l. longulus* at all stations.



FIGURE 21.—*Xironodrilus formosus*: a, dorsal view of entire animal; b, ventral view of male reproductive system; c, upper jaw; d, lower jaw.

Ostracod associates include *An. ancylla* at stations 88, 89, 92; *Dn. ardis* and *Dn. ileata* at 10, 21; *Dn. truncata* at 88, 90–91; *Dt. falcata* at 88–92, 112; and *E. internotatus* at 88 and 90.

Branchiobdellid associates include *A. koronaeus* and *C. branchiophila* at stations 88–92, 112; *C. fallax* at 88, 89, 91, 92; *C. holostoma* at 10, 21; *C. philadelphica* at all stations; and *Xg. instabilis* at 21.

REMARKS.—*Xironodrilus formosus* was associated with the riffle-inhabiting *Cambarus l. longulus* in every locality that this worm occurred and may be ecologically restricted to much the same habitat. No conclusions as to host specificity should be drawn from this association, however, for most of the range of *Xl. formosus* is outside that of *C. l. longulus*.

Genus *Xironogiton* Ellis, 1919

DIAGNOSIS.—Body terete anteriorly, depressed posteriorly (“tennis racquet-shaped”); peristomium entire; posterior sucker ventral; spermiducal gland long and tubular, deferent ducts entering near its midlength, prostate absent; bursa large and asymmetrical; spermatheca very small.

Xironogiton instabilus (Moore)

FIGURES 22a-d

Branchiobdella instabilia Moore, 1894, p. 425.*Bdelodrilus instabilus* Pierantoni, 1912, p. 22.*Xironogiton instabilus* Ellis, 1919, p. 252.*Xironogiton instabilus instabilus* Goodnight, 1940, p. 45.

DIAGNOSIS.—Dental formula 5/5 or 4/4, teeth irregular in shape with some median teeth shorter than lateral ones on both jaws.

RANGE.—Swift, colder streams of the mountains from Ontario to Georgia; a form at present indistinguishable from *Xg. instabilus* is the most common branchiobdellid in the streams of the western slopes of the Sierra Nevada and Cascade Mountains of California, Oregon, and Washington west to the Pacific Ocean.

SPECIMENS EXAMINED.—More than 100 specimens in 24 collections from the following stations: 3-5, 7, 9, 11-13, 21, 22, 24, 37, 44, 46, 53,

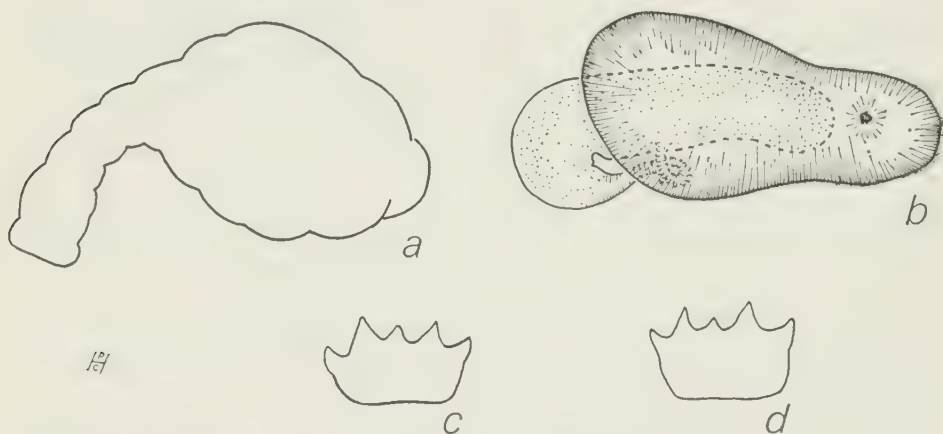


FIGURE 22.—*Xironogiton instabilus*: a, dorsal view of entire animal; b, ventral view of bursa and spermiducal gland; c, upper jaw; d, lower jaw.

54, 60, 61, 64, 86, 95, 97, 121, and 123. These stations are in the headwaters or swifter tributaries of the James and New river drainages at elevations of 512 to 1097 m.

HOSTS AND ASSOCIATES.—*Xironogiton instabilus* was associated with *Cambarus b. bartonii* at all stations except 11, 13, 61, 86; with *C. carolinus* at 22; with *C. l. longulus* at 7, 9, 11, 12, 13, 21, 22, 37, 123; with *C. sciotoensis* at 3, 5, 44, 54, 61, 64, 86, 95, 97; and with *O. juvenilis* at 7.

Ostracod associates includes *As. asceta* and *Dt. chalaza* at station 22; *Dn. ardis* at 11-13, 21, 37, 123; *Dn. ileata* at all stations except 13, 53, 121; *Dn. scalis* at 7, 44; *Dn. truncata* at 53, 54; *E. kanawhaensis* at 44; and *P. phyma* at 3, 5, 7, 24, 44, and 64.

Branchiobdellid associates include *B. illuminatus* at stations 5, 22, 44, 86, 97, 121; *C. branchiophila* at 24, 86, 97; *C. fallax* at 3, 5, 24, 54, 61, 86, 95, 97; *C. heterognatha* at 3-5, 24, 61, 64, 86, 97, 123; *C. holostoma* at 7, 11, 13, 21, 22, 37; *C. ingens* at 5, 54, 61, 64, 86, 95, 97; *C. philadelphica* at 3, 5, 9, 12, 21, 22, 24, 37, 44, 46, 53, 54, 60, 121, 123; *P. alcornus* at 3-5, 24, 61, 64, 86, 95, 97; and *Xd. formosus* at 21.

Discussion

Since the crayfishes in the area serve as hosts to the epizoötic ostracods and branchiobdellids and since, in this area, neither of the latter is known to occur independently of their hosts, it seems highly probable that they reached the Mountain Lake region on one or more of the crayfish stocks. If this likelihood can be accepted, a knowledge of the probable origin of the crayfish fauna may help to explain, in part, some of the associations that have been recorded above.

One of the crayfishes, *Cambarus b. bartonii*, is at home in the Appalachian Mountain system, and probably had its origin in the southern part, migrating in postglacial times as far north as New Brunswick, Canada. This crayfish ascends the smallest headwater streams, burrows in seepages, springs, and along water courses; furthermore, it is not averse to leaving the aquatic habitat to crawl about on land. These habits would, of course, enable it to ignore narrow terrestrial barriers between headwater streams, and, consequently, it is not surprising that it occurs in all three river systems in the Mountain Lake Region.

Cambarus sciotoensis, a not-so-distant relative of *C. b. bartonii*, appears to be confined to the Ohio drainage system in the Kanawha and Scioto tributaries, where it seeks cover beneath stones or in vegetation throughout most of the stream bed. Its range is not adequately known, but it seems probable that it reached this area through migrations up the Kanawha and New Rivers, and here it is confined to the New River drainage.

Cambarus l. longulus, probably the most primitive member of the genus in the area, almost certainly has reached its present range by the migration of its ancestors from the southwest (Coosa-Tennessee drainage systems) leaving populations in the Tennessee (*C. l. longirostris* Faxon) and New (*C. l. chasmodactylus* James) systems. The typical subspecies is found in the lower mountains and Piedmont provinces from the James River to the Yadkin River in Virginia and North Carolina. Although perhaps exhibiting a larger number of generalized characteristics than other members of the genus in the area, it is almost as ecologically restricted as *C. carolinus* in that here it is confined to riffles in tributaries of the James and Roanoke Rivers.

The range of *Cambarus acuminatus* and its relatives forms an asym-

metrical U around the Appalachian Mountains, extending from the eastern Great Lakes area southward along the western slopes, eastward around the southern portion of the Blue Ridge, and northward to Maryland. The ancestors of this stock probably arose from a southern Appalachian *C. extraneus* stock and spread northward on both sides of the mountains. There is little doubt that *C. acuminatus* arose in the foothills of the southern Blue Ridge and spread northward along the Atlantic slopes to southern Maryland, an area in which it is characteristic of the nonriffle portions of most of the lower mountain and piedmont streams. In areas of the northern part of its range, it even frequents streams in the lower coastal plain. In the Mountain Lake area it occurs, like *C. l. longulus*, in the James and Roanoke drainage systems.

Cambarus carolinus is, in another way, equally as restricted in its ecological requirements as is *C. l. longulus*, frequenting ground water which it reaches through burrowing. Like the latter, it gained access to the area along the western slopes of the Appalachian system, if not from the south then from an original home to the west, probably not far from this area. This crayfish habitually leaves its burrows after dark following or during rains and often wanders some distance from its tunnels. Not infrequently it has been seen crossing roads and crawling about open areas where there are few or no obvious burrows; consequently, an absence of standing surface water is not a serious deterrent to the migration of this crayfish, and, therefore, it is not surprising to find that it has crossed the divide into both the New and James watersheds.

Although *Orconectes juvenilis* is native to the Ohio drainage system, its presence in the Mountain Lake area is almost certainly attributable to introductions. It has demonstrated a remarkable vigor both in Mountain Lake proper, where it has apparently brought about the expulsion of other crayfishes, and in Potts Creek, where it seems to be making notable progress in taking over most of the crayfish niches. The sources of the introduced stocks have not been ascertained, but it is highly probable that the animals were obtained from either (or both) the New or Tennessee systems in West Virginia and Virginia, respectively. To summarize briefly, the presence of the crayfishes in the Mountain Lake region may be explained as follows:

Cambarus acuminatus—by migrations along the Atlantic slope from the southeast.

Cambarus b. bartonii—originated in or near the area.

Cambarus carolinus—originated in the area or by migrations from the southwest.

Cambarus l. longulus—by migrations from the southwest via the Tennessee and New Rivers to the Atlantic slope, probably along the James, and from it to the Roanoke.

Cambarus sciotensis—by migrations from the west along the New River.

Orconectes juvenilis—by introductions in Potts Creek and in Mountain Lake proper and by recent migrations from the west in New River.

Despite overwhelming evidence for a lack of host specificity for most of the ostracod and branchiobdellid symbionts, it is highly probable that all of them or their ancestors have reached the area as passive migrants on one or more of the crayfish stocks presently represented in the area. Too, it is scarcely to be denied that the association of certain ostracods with a particular crayfish is in a few instances apparently absolute, and most of the ostracods tend to "favor" one or two crayfish species. Among the ostracods that have evolved nearby or within the Mountain Lake area are the monotypic *Phymocythere phyma*, and three species of the genus *Donnaldsoncythere*: *Dn. ardis*, *Dn. ileata*, and *Dn. truncata*. As nearly as can be ascertained at the present, the genus *Donnaldsoncythere* has as its center of distribution the Appalachian Mountains, and *Dn. ardis* and *Dn. truncata* are confined to the general Mountain Lake region. *Dn. scalis*, which is also known from two localities in Pennsylvania and one in New York, is largely restricted in the Mountain Lake area to the higher altitudes in the James and New drainages, where *Cambarus b. bartonii* is the usual host. *Dn. ardis*, endemic in the James drainage, occurs at lower altitudes primarily on *Cambarus l. longulus*. *Dn. truncata* appears to be confined to lower elevations in the Roanoke and New drainage systems, where the principal hosts are *C. acuminatus*, *C. b. bartonii*, and *C. sciotensis*. *Dn. ileata*, known from a number of localities in the New River (Kanawha) system to the west of the Mountain Lake area, occurs in all three drainage systems and on all the species of crayfishes in the area except *C. carolinus*. In this group of four closely related ostracods it seems likely that three of them might well have evolved from a common stock that became, for a time, isolated in the three drainage systems studied here: *Dn. ardis* in the James, *Dn. ileata* in the New, and *Dn. truncata* in the Roanoke. *Dn. scalis* probably arose in some stream to the north (its range is too poorly known at present to be more specific), and it has been introduced by *C. b. bartonii* into the Mountain Lake area at higher elevations, apparently first reaching the James drainage and later being transported, presumably by the same crayfish, to the headwaters of the New River. The absence of *Dn. scalis* from the Roanoke River can perhaps be explained by the fact that the headwater streams occur at too low an elevation for the species—certainly the maximum elevation of the system in the area under consideration is marginal for the species. With *Dn. scalis*

occupying the smaller tributaries at higher elevations (even now, except in one locality on Potts Creek, above 890 m), the ancestors of *Dn. ardis* had access to the lower elevations (below 625 m) in the James River drainage. Through migrations of *C. b. bartonii* overland between headwater streams, *Dn. ileata* was introduced from the New River into the James River, where it is widespread in the Mountain Lake area, and, although less well established in the Roanoke River, it has been found in one locality there. Two sources of evidence provide the basis for the hypothesis that *Dn. truncata* originated in the Roanoke River and later reached the New River, because (1) only *Dn. truncata* and *Dn. ileata* (the latter of which is abundant in the New and James drainages but represented in only one station in the Roanoke) are found in the Roanoke, and (2) Burton and Odum (1945, pp. 192-193) indicated that two "Atlantic coast" fishes are found in the New River system, suggesting that streams of the New River system had pirated tributaries of the James. Now there are data that support equally well a tapping of the Roanoke River by the New River (R. D. Ross, pers. comm.). Even if stream piracy were highly improbable, there is no reason why *C. b. bartonii*, one of the principal hosts of the species, could not cross the relatively low divide between tributaries of Indian Run or Cedar Run (to Roanoke) and Slate Branch or Toms Creek (to New).

The monotypic *Phymocythere phyma*, the closest relatives of which are members of the genus *Ascetocythere*, is probably a somewhat degenerate offshoot (reduced clasping apparatus and unadorned swollen subterminal area of the peniferum) from the *Ascetocythere* stock that has forsaken the groundwater environment and ventured into competition with other ostracods frequenting lotic surface habitats. In terms of numbers of individuals, it does not appear to have been spectacularly successful. Supporting the assumption of the close relationship of *Phymocythere* to *Ascetocythere* is their apparent commonly shared preference for living among the setiferous areas of the mouthparts of their hosts.

The single ostracod that seems to have been derived from a stock reaching the area from the west is *Entocythere kanawhaensis*, which probably arrived on *Cambarus sciotensis*; close relatives of this ostracod are known from the west and south.

Four species apparently are derived from stocks that have moved into the area from the southwest although the ancestral home of the two genera is in the southern Appalachians and Cumberland Plateau; thus, any of them conceivably might have had their origin in this region. Ancestors of *Ascetocythere asceta* undoubtedly arrived in the area on the *C. carolinus* stock, the range of which is almost congruent with that of the genus *Ascetocythere*; furthermore, *As. asceta* is not

known to occur on any other host. Also sharing the same host is *Dactyocythere chalaza*, which, in contrast to *Phymocythere phyma*, was derived from a stock that is primarily associated with lotic habitats but which invaded the groundwater in adopting *C. carolinus* as a host; it is not improbable that this crayfish brought the progenitors of *Dt. chalaza* with it when it moved into the area. The third species postulated to have arrived in the area from the southwest is *Dt. daphnioides*, which, in the Mountain Lake region, is associated with only one crayfish, *C. sciotensis*, but outside of the area (in the New, Watauga, and Pound drainages) it infests several species, including *C. b. bartonii*. The fourth species, *Dt. falcata*, insofar as is presently known, has a discontinuous distribution and probably reached the Roanoke River from the southwest, perhaps following the same route as proposed for *Dn. truncata* in getting from the New into the Roanoke basin. The perplexing problem of *Dt. falcata* not having been found in the New River leads to speculation that it may have been routed by other species there, perhaps one or more of its close relatives.

Southeastern components of the entocytherine fauna of the region include *Entocythere internotalus*, *Dt. suteri*, and *An. ancyla*. The principal hosts of all three of these species are *C. acuminatus* and *C. l. longulus*, and it is likely that *C. acuminatus* has been more important in the dispersal of these three than has *C. l. longulus*, not only because of its larger surface area and broader ecological tolerance, but also because its range far exceeds that of the smaller species. In summary, the presence of the ostracods in the Mountain Lake region may be explained as follows:

Asctocythere asceta, *Dactyocythere chalaza*, *Dt. daphnioides*, and *Dt. falcata*—by migrations from the southwest along the Tennessee and New drainage systems.
Ankyocythere ancyla, *Entocythere internotalus*, and *Dt. suteri*—by migrations along the Atlantic slope from the southeast.

Donnaldsoncythere ardis, *Dn. ileata*, *Dn. truncata*, and *Phymocythere phyma*—originated in or near the area.

Donnaldsoncythere scalis—by migrations from the north into the James drainage.
Entocythere kanawhaensis—from the west along the Kanawha and New rivers.

Two-thirds of the branchiobdellids of the Mountain Lake area are endemic to the southern Appalachians. Of the remainder, *Xg. instabilis* is confined to mountain streams, at relatively high elevations throughout the Appalachians, but it is indistinguishable from the western *Xg. oregonensis*. The greater number of species of *Xironogiton* are found to the west of the continental divide, and one must assume that the present disjunct distribution of the genus is a relict of a former continuous range. The monotypic *Bdellodrilus illuminatus* is widely distributed over North America. At this time few inferences can be drawn as to place of origin, migration routes, or evolution of this

species, which, in some respects, is the most primitive of North American branchiobdellids, and, in other respects (its parasitic habitus), among the more highly specialized. Probably an early branchiobdellid stock acquired the parasitic habit, is now widely distributed, and has undergone (because of its confinement to branchial chambers of the various hosts [?]) little or no evolutionary diversification. A possible caveat to this conclusion must be entered because of the lack of taxonomic studies of *B. illuminatus*; further study may show that some of the widely disjunct populations (e.g., those from the Pacific drainage in Mexico and California) assigned to this species are actually other disjunct species. *Xd. formosus* is more common in the Ohio drainage in Kentucky, Tennessee (Cumberland drainage), Ohio, and West Virginia than in Virginia, but the greatest number of the species are from the Great Lakes region, primarily in Michigan. Yet the genus, with the exception of *Xd. formosus*, appears to be confined to the southern Appalachians and the Ozarks. *Xironodrilus formosus* is a primitive species within the genus (and the order), and one must postulate a post-Pleistocene invasion of the Great Lakes from the South and attribute a relict status to the populations in the James and Roanoke Rivers. This conclusion has been reached because (1) the distribution of the species (and the genus) is such that we can only assume that it reached the Roanoke and James by way of the New, and (2) that the genus originated within either the New or Tennessee systems, most likely the New, since the ancient Teays River and the Illinois Ozarks would link the Appalachian and Ozarkian progenitors of the modern species and leave relict populations along the present Ohio as a source for the invasion of the Great Lakes. The remaining widespread species, *C. philadelphia*, is clearly one of Appalachian origin that has spread from the mountains into the piedmont and, to the north, the coastal plain; the western limits of *C. philadelphia* are in the interior plateau regions of Tennessee, Kentucky, and Ohio, although there is evidence here that it intergrades with the Ozarkian *C. chirocephala*, and there is one anomalous record from Wisconsin. It is futile to speculate about the origins of *B. illuminatus* and *Xg. instabilis*; they are bound to the ancient invasion of the continent by the ancestors of the order. *Cambarincola philadelphia* and *Xd. formosus*, the former the dominant branchiobdellid species of eastern North America and the latter a primitive species fragmented into disjunct populations, are, however, derived from early inhabitants of either the Tennessee or New Rivers, more likely the New.

The remaining two-thirds of the species are at home in the area. *C. branchiophila* is a gill-inhabiting branchiobdellid known only from the Mountain Lake area, where it is found associated with all the crayfishes except the burrowing *C. carolinus* and the introduced *Orconectes*

juvenilis. *Cambarincola branchiophila* is apparently more common in the New River system, 18 occurrences as compared to 4 in the James and 9 in the Roanoke, but this may be a sampling artifact (table 1). The species appears to belong to a primitive section of the genus, and its closest relative is *C. shoshone* Hoffman (1963, p. 319) from the Snake River drainage in Idaho. As a putatively relict species that has survived in the area as a consequence of the adoption of the gill-parasitic habit, the only clue as to its origin is the general importance of the New River as the source of the branchiobdellid fauna of the region from which the invasion of the upper reaches of the James and Roanoke is easily understandable either through stream captures, which have indubitably occurred, or the overland wandering of *C. b. bartonii*.

Ankyrodrilus koronaeus is likewise confined to the streams in the area, occurring in all three of the drainages, but it has been found outside the area in Botetourt County, Va., in the Roanoke drainage. But *A. legaeus*, with only one record in the area from Wolf Creek of the New River, is really a species of the Tennessee drainage, extending from southwest Virginia to middle Tennessee, where it is found in the Cumberland River drainage. At this time, the phylogenetic position of *Ankyrodrilus* is obscure: one of us (Holt, 1965, p. 10) has pointed out previously the similarities, mostly in body form, of the genus to *Xironodrilus* and *Xironogiton*, yet a further consideration of the male reproductive system leads to the tentative conclusion that *Ankyrodrilus* may be most closely related to the eastern Asian *Cirrodrilus*. The genus would appear to be a survival in the southern Appalachians of a formerly more widespread group and has reached the Mountain Lake area from the Tennessee and Cumberland systems by way of the Clinch or Holston Rivers.

Pterodrilus alcornus is a member of a genus, clearly an offshoot of *Cambarincola*, that is centered in the southern Appalachian-Ozark region with an outlier, *P. distichus*, which is found primarily in the glaciated areas around the Great Lakes, and possibly another, *P. mexicanus*, in southeastern Mexico. *Pterodrilus alcornus* is a species of the Tennessee system and has reached the New River from the southwest and hence to the James. The species is not known from the Roanoke.

Of the remaining species of the genus *Cambarincola*, *C. holostoma* is known only from the James, Potomac, and New river basins. But it is most common in the James system (Potts, Craig, and Johns Creeks), with two records from Sinking Creek and one record (Hoffman, 1963, p. 360) from the Potomac drainage. The conclusion that *C. holostoma* is a specialized derivative of a *C. philadelphia* stock that arose in the upper tributaries of the James River is inescapable. *Cambarincola ingens*, common in the Tennessee drainage southward to northeastern

TABLE 1.—Summary of geographical and altitudinal distribution and associations of the crayfishes, entocytherids, and branchiobdellids of the Mountain Lake Region (J=James; N=New; R=Roanoke)

Animal	Drainage systems	Altitude (meters)	Crayfishes	Ostracods	Branchiobdellids
I. <i>C. acuminatus</i>	JR	402-535	II, IV	1, 3, 4, 6, 9, 10, 11	acdegik
II. <i>C. b. bartonii</i>	JNR	427-1219	I, IV, V, VI	1, 3, 4, 5, 6, 9, 10, 11, 12, 13	acdefghijkl
III. <i>C. carolinus</i>	JN	585-1250		2, 7	ce
IV. <i>C. l. longulus</i>	JR	402-686	I, II, VI	1, 3, 4, 6, 9, 10, 11	acdefgijkl
V. <i>C. sciotensis</i>	N	427-899	II	4, 5, 6, 8, 12, 13	abcdefgghijl
VI. <i>O. juvenilis</i>	JN	671-1180	II, IV	4, 5, 13	gl
1. <i>An. ancyla</i>	R	439-475	I, II, IV	6, 9, 11	adeik
2. <i>As. asceta</i>	JN	585-1250	III	7	ce
3. <i>Dn. ardis</i>	J	402-622	I, II, IV	4, 10, 11	acdfgijkl
4. <i>Dn. ileata</i>	JNR	415-899	I, II, IV, V, VI	3, 5, 6, 8, 10, 11, 12, 13	abcdefgghijkl
5. <i>Dn. scalis</i>	JN	671-1219	II, V, VI	4, 9, 12, 13	cil
6. <i>Dn. truncata</i>	NR	445-625	I, II, IV, V	1, 4, 9, 11	acdebikl
7. <i>Dt. chalaza</i>	JN	585-1250	III	2	ce
8. <i>Dt. daphnioides</i>	N	488-561	V	4	abdefhj
9. <i>Dt. falcata</i>	R	439-597	I, II, IV	1, 6, 11	acdeik
10. <i>Dt. suteri</i>	J	402-482	I, II, IV	3, 4, 11	ai
11. <i>E. internotalus</i>	JR	402-475	I, II, IV	1, 3, 4, 6, 9, 10	adegik
12. <i>E. kanawhaensis</i>	N	500-899	II, V	4, 5, 13	cdefil
13. <i>P. phyma</i>	JN	610-1143	II, V, VI	4, 5, 12	cdefghijl
a. <i>A. koronaeus</i>	JNR	402-750	I, II, IV, V	1, 3, 4, 6, 8, 9, 10, 11	cdefghijk
b. <i>A. legaeus</i>	N	488	V	4, 8	defhj
c. <i>B. illuminatus</i>	JNR	518-1250	I, II, III, IV, V	2, 3, 4, 5, 6, 7, 9, 12, 13	adefghijl
d. <i>C. branchiophila</i>	JNR	427-777	I, II, IV, V	1, 3, 4, 6, 8, 9, 11, 12, 13	abcefgghijkl

TABLE 1.—Summary of geographical and altitudinal distribution and associations of the crayfishes, entocytherids, and branchiobdellids of the Mountain Lake Region (J=James; N=New; R=Roanoke)—Continued

Animal	Drainage systems	Altitude (meters)	Crayfishes	Ostracods	Branchiobdellids
e. <i>C. fallax</i>	JNR	439-1158	I, II, III, IV, V	1, 2, 4, 6, 7, 8, 9, 11, 12, 13	abedfghijkl
f. <i>C. heterognatha</i>	JN	451-838	II, IV, V	3, 4, 8, 12, 13	abcedehijl
g. <i>C. holostoma</i>	JN	512-671	I, II, IV, V, VI	2, 3, 4, 5, 7, 11, 13	acdehijkl
h. <i>C. ingens</i>	N	488-777	II, V	4, 6, 8, 13	abcedefgijl
i. <i>C. philadelphia</i>	JNR	427-1170	I, II, III, IV, V	1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12, 13	acdefghijkl
j. <i>P. alcicornus</i>	JN	488-838	II, IV, V	3, 4, 8, 13	abcedefghijl
k. <i>Xd. formosus</i>	JR	439-561	I, II, IV	1, 3, 4, 6, 9, 11	adegil
l. <i>Xg. instabilus</i>	JN	512-1097	II, IV, V, VI	2, 3, 4, 5, 6, 7, 12, 13	cdefghijk

Georgia and confined to the New River and its tributaries in the area, is another specialized offshoot of the *C. philadelphia* stock that has reached the Mountain Lake region from the south. There is one record from Patrick County, Va., in the Roanoke drainage (Hoffman, 1963, p. 335); the remaining records from outside the area are from the mountain streams of the New and Tennessee drainages. *Cambarincola ingens* is a Blue Ridge species, but it is impossible to decide whether it evolved in the headwaters of the New River in North Carolina or in those of the Tennessee River in the same region. *Cambarincola heterognatha* is known from the Potomac southeastward through the mountains in the New, Cumberland, and Tennessee river systems, with one isolated record in the Roanoke drainage (Franklin County, Va.). Again, we are dealing with a species, widespread in the mountains, that appears to have spread into the Tennessee drainage. The alternative possibility of an origin in the Tennessee may be as likely, and there is no way now to decide between these choices. Finally, *C. fallax* is not quite so widespread as *C. philadelphia*, but it

is abundant throughout the southern Appalachians. Our information suggests that *C. fallax* has reached the James and Roanoke from the New, but it does not indicate any choice between the New or the Tennessee as the ancestral home of the species. In summary, the presence of the branchiobdellids in the Mountain Lake region may be explained as follows:

Ankyrodrilus koronaeus—originated in or near the area, but derived from a Cumberland Plateau group by way of the Tennessee drainage.

Ankyrodrilus legaeus—by migrations from the Cumberland Plateau region by way of the Tennessee drainage.

Bdellodrilus illuminatus—unknown origin (ancient, widespread).

Cambarincola branchiophila—New River endemic, relict survivor of a once wider range.

Cambarincola fallax—a southern Appalachian species (now widespread in eastern highlands) that reached James and Roanoke from New.

Cambarincola heterognatha—New River native.

Cambarincola holostoma—James River native, evolved from *C. philadelphia* stock.

Cambarincola ingens—by migrations from the south, headwaters of New or Tennessee.

Cambarincola philadelphia—Appalachian (widespread).

Pterodrilus alcornus—Tennessee drainage.

Xironodrilus formosus—relict of ancient Teays River fauna.

Xironogiton instabilis—unknown origin (ancient relict).

It has been pointed out above that evidence exists that most of the ostracods tend to favor one or more crayfish hosts. The extreme of this favoritism is demonstrated in the relationship between *C. carolinus* and its two "riders," *As. asceta* and *Dt. chalaza*, in which the associations appear to be absolute for the ostracods. (As has already been suggested, the "favoritism" probably has more to do with the environment of the host than with physiological relationships usually associated with "host specificity.") The opposite extreme is demonstrated in an apparent lack of discrimination on the part of the ostracod *Dn. ileata* that infests all the crayfishes in the area except *C. carolinus* and is associated with it in other areas. The affinities of other ostracods for one or two particular hosts seem to lie somewhere between these two extremes.

What the nature of the ties is between the ostracod symbionts and the crayfish hosts and between the branchiobdellid symbionts and the crayfish hosts has not been critically analyzed. It cannot be said that the ostracod relationship is parasitic even in the sense that they have free transportation and pasturage, for they might well be paying a service charge in ridding the crayfish of foreign organic matter that adheres particularly to the setiferous areas of the exoskeleton. While they may not do a thorough cleaning job, the accumulation of such matter is probably retarded.

There are instances of branchiobdellids known from only one host species, but these are associations in which the worm is known from only one or a few collections. The one such association of this type from our collections (*A. legatus* on *Cambarus sciotensis*) clearly does not indicate host-species specificity since *A. legatus* is known from other species of crayfishes outside of the Mountain Lake area (Holt, 1965, p. 12). Similarly, the associations (table 1) in which it might appear that there is a "preference" by a branchiobdellid species for one or another host species are surely to be interpreted as the consequence of the ecological relationships of hosts and worms or as the product of the migration (distribution) patterns of the two. Host specificity in the sense of host-species specificity is not an important feature of the relationship between the annelids and the crustaceans; yet, the relationship is an obligate one for the branchiobdellids.

In occupying the exoskeleton of the crayfish host, the ostracods and branchiobdellids have found niches that remind one of the occupation of a stream by two or more species of crayfishes. Although detailed observations on the distribution of the ostracods on their hosts are limited to those that are reported above, it is reasonable to assume that most multiple infestations result in a partial segregation of the species on different areas of the host, similar to that exemplified by *As. asceta* and *Dt. chalaza* on *C. carolinus*, in which the former is concentrated among the setae of the gnathal appendages and the latter on the setiferous portions of the abdomen. In terms of obvious morphological adaptations to microhabitats on the crayfishes, the ostracods have not approached the refinements exhibited by some of the branchiobdellids (see p. 8). The contrast in body form of the vermiform, gill-inhabiting *B. illuminatus*, the plumose, venter-dwelling *P. aleicornus*, and the depressed, tennis-racquet-shaped, chela-dwelling *Xg. instabilis* reflect the extreme conspicuous adaptive modifications accomplished by the members of this order in becoming specialized for a particular microhabitat on the crayfish host. Even in the absence of such adaptive features, there must be equally strong as yet unrecognized ones that are in effect in the ostracods, for in the associations just mentioned the gnathal areas of all specimens of *C. carolinus* examined were dominated by *As. asceta* and the abdominal region by *Dt. chalaza*.

While the adaptations of the crayfishes to riffles and pools are not so conspicuous as those among the branchiobdellids in their modifications for living on different body regions of the crayfish, the riffle-dwelling *C. l. longulus* is smaller, less spiny, and has smoother chelae than the pool-dwelling *C. acuminatus*. The burrowing *C. carolinus*, in contrast to *C. l. longulus*, has a compressed rather than depressed

thorax, a longer, narrower areola signifying a more spacious gill chamber, a less pointed rostrum, and more tuberculate and sharper-tipped chelae.

Although a number of references have been made by us to the associations between the epizoites and their hosts, it is not an omission on our part that we have scarcely alluded to the relationships existing between the branchiobdellids and the entocytherids. It seems probable that the gill-inhabiting branchiobdellids, *B. illuminatus* and *C. branchiophila*, probably have few contacts with the entocytherids for, as pointed out, we have not encountered a single ostracod within the gill chamber of the crayfish. Furthermore, contacts between *Xg. instabilis*, the branchiobdellid that is almost confined to the chela of the host, would also have little cause for encountering an ostracod, for the latter has not been observed to inhabit the chelae of the hosts. In contrast, most of the members of the genus *Cambarincola*, the two members of *Ankyrodrilus*, *P. aleicornus*, and *Xd. formosus* do undoubtedly encounter the ostracods in the course of their moving about the ventral part of the thoracic and abdominal areas of the crayfish. Even though the methods of feeding of the branchiobdellids and ostracods may be different, in view of the fact that they share the same source of food scraped from the exoskeleton of the host, there must be some degree of competition between them, however slight the intensity of the competition might be. Furthermore, inasmuch as several of the branchiobdellids are known to feed on other animals, even other branchiobdellids, that dwell on the crayfish, it is a bit surprising that there is no record of their having ingested an entocytherid ostracod. One cannot help posing the question as to the nature of the immunity of the entocytherids from the apparently voracious appetite of their fellow epizoites! There are some data that indicate that crayfishes heavily infested with branchiobdellids seldom, if ever, have large numbers of ostracods.

Two studies have been made elsewhere that are similar to that undertaken here. Crawford (1959) treated the crayfishes and their ostracod associates of Richland County, S.C., and Simonds⁴ conducted a study of the crayfishes and their ostracod and branchiobdellid symbionts of the Hiwassee drainage system in Georgia, North Carolina, and Tennessee. In both studies, only a single drainage system was involved, the former dealing with the Santee river system and the latter with a major tributary of the Tennessee-Ohio river system.

Crawford found that within Richland County there were 11 species

⁴ Kenneth W. Simonds conducted this survey of the Hiwassee drainage system in the late 1950s; however, a final report was not completed and no publications have been derived from the survey except the descriptions of new species of ostracods by Hobbs and Walton (1960, 1961).

of crayfishes belonging to three genera, *Procambarus* (4 species), *Cambarus* (6 species, 2 of which, *C. b. bartonii* and *C. acuminatus*, are also present in the Mountain Lake region), and *Orconectes clypeatus* (= *Faxonella clypeata*). Infesting these crayfishes were six species of entocytherids (the first two of the following list occur also in the Mountain Lake region): *Entocythere internotalus*, *Dactylocythere suteri*, *Dt. striophylax*, *Ankylocythere telmoceea*, *An. tiphophyla*, and *An. hobbsi* (Hoff)—all except the latter described as new in his report. The most outstanding difference between the faunas of the Santee River and the Mountain Lake region is the number of species of each

TABLE 2.—Major streams, altitude ranges, stations, and numbers of species in the Mountain Lake Region

Streams	Altitudes (meters)	Stations	Cray- fishes	Ostra- cods	Branchi- obdellids	Totals
James River						
Craig Creek	384-853	30, 31, 32, 33, 34, 35, 36, 37, 122, 123, 124	3	4	6	13
Johns Creek	384-1219	9, 10, 11, 12, 13, 17, 20, 21, 22, 23, 24, 25, 26, 27, 28, 68, 100, 103	4	8	9	21
Meadow Creek	390-811	29, 98, 125	3	1	5	9
Potts Creek	671-1085	6, 7, 8	4	5	3	12
New River	384-524	26, 57	2	3	3	8
Doe Creek	500-1067	45, 113, 118, 119	1	1	3	5
Big Stony Creek	488-1067	3, 4, 5, 43, 62, 63, 64, 65, 66, 67, 86, 97, 99, 102, 127	3	4	8	15
Little Stony Creek	500-1250	1, 2, 16, 38, 39, 40, 41, 42, 44, 59, 60, 61, 82, 83, 101, 114, 115, 120, 121	4	6	7	17
Sinking Creek	518-1067	14, 15, 18, 19, 46, 47, 48, 49, 50, 51, 52, 58, 84, 95, 96	2	1	10	13
Spruce Run	506-671	53, 54, 55, 56	2	2	5	9
Toms Creek	524-738	94, 104, 105, 106, 107, 108, 109, 117	2	2	5	9
Wolf and Mill Creeks	472-1067	80, 81	1	2	6	9
Roanoke River						
North Fork	411-756	85, 87, 88, 89, 90, 91, 92, 93, 110, 111, 112	3	5	6	14

group—in the Santee, there are 11 crayfishes, 6 ostracods, and 4 branchiobdellids; in the Mountain Lake region there are 6, 13, and 12, respectively (see table 3 for the numbers in the three river systems in the area). Both species of crayfishes common to the two areas occur in the Roanoke and James drainages, and *C. b. bartonii* is also present in the New; both of the ostracods common to the two occur in the James and one of them in the Roanoke drainage. Of the four species of branchiobdellids present in the Santee, two of them, *B. illuminatus* and *C. philadelphia*, occur in all three drainages of the Mountain Lake area.

Simonds has provided us with a summary chart of his findings and the numbers of species present are recorded in table 3. Two crayfish common to the two areas, *C. carolinus* and *C. b. bartonii*, are found in the James and New drainages and the latter also in the Roanoke. Of the two species of ostracods shared in common, *Dt. falcata* and *E. internotatus*, the former occurs in the Roanoke and the latter in the James and New drainages. Of the five branchiobdellids found in the two regions, *B. illuminatus*, *C. fallax*, and *C. philadelphia* occur in all three drainages of the Mountain Lake area, *C. heterognatha* in the James and New, and *C. ingens* in the New.

Only three of the animals mentioned above occur in all five drainage systems: one crayfish, *C. b. bartonii*, and two branchiobdellids, *B. illuminatus* and *C. philadelphia*.

The only comparative faunistic study of the drainage systems in the Mountain Lake area is that of Burton and Odum (1945), in which they compared the fish faunas of certain tributaries of the New and James Rivers. Table 5 presents one of their comparisons and summarizes our findings in the same streams. From the standpoint of the fishes, Craig and Sinking Creeks and Craig and Spruce Runs share the greatest number of species and Johns and Little Stony the least; in contrast, using the totals of the three groups studied by us, Johns and Little Stony have the most in common and Craig and Spruce Run the least. Similarities and differences in our findings may be found in the table. There is abundant evidence for multiple faunal interchanges between the three river systems in the Mountain Lake area but these data have never been brought together. Suffice it to say here that the New River fauna is the principal component of the crayfish-entocytherid-branchiobdellid fauna of the region as here defined, and the Tennessee basin has served as the chief pathway for the migrations of stocks into the region. The Roanoke basin apparently has contributed the least. Not only is the Roanoke the smallest and has the least ecological diversity of the three river systems in the region, but also there appear to have been fewer ancient ancestral stocks of crayfishes, entocytherids, and branchiobdellids in it.

TABLE 3.—Numbers of species occurring in the major drainage systems of the Mountain Lake Region, the Santee (Richland County, S.C.) and Hiwassee (Georgia, North Carolina, and Tennessee) Rivers

Drainage	Crayfishes	Ostracods	Branchiobdellids	Totals
James	5	8	10	23
New	4	8	11	23
Roanoke	3	5	6	14
Santee ¹	11	6	4	21
Hiwassee ²	11	10	9	30

¹ Except for numbers of branchiobdellids (original data), from Crawford, 1959.

² From Simonds (see ftn., p. 76).

TABLE 4.—Numbers of species restricted to the drainage system or combinations of systems indicated

Drainage	Crayfishes	Ostracods	Branchiobdellids	Totals
James, New, Roanoke	1	1	5	7
James, New	2	4	4	10
James, Roanoke	2	1	1	4
New, Roanoke	0	1	0	1
James	0	2	0	2
New	1	2	2	5
Roanoke	0	2	0	2
Totals	6	13	12	31

TABLE 5.—Summary of similarities and differences in the crayfish, entocytherid, branchiobdellid, and fish faunas in selected streams in the Mountain Lake Region (S=number of species shared in common by the two streams; D=number of species found in both streams that are not shared in common)

Streams		Crayfishes		Ostracods		Branchiobdellids		Totals		Fishes ¹	
James Drainage	New Drainage	S	D	S	D	S	D	S	D	S	D
Craig	Sinking	1	3	1	3	6	4	8	10	8	27
Craig	Spruce Run	1	3	1	4	2	7	4	14	8	23
Johns	Sinking	1	4	1	7	7	3	9	14	7 ²	23
Johns	Spruce Run	1	4	1	8	4	6	6	18	5	25
Craig	Little Stony	1	5	1	8	4	5	6	18	3	22
Johns	Little Stony	2	4	5	4	6	4	13	12	2	20

¹ Compiled from Burton and Odum, 1945, table vi.

² Given as 6 by Burton and Odum, p. 192, but according to table vi, 7 species are shared in common.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3603

The Species of *Hermetia* of the *aurata* Group (Diptera: Stratiomyidae)

By Maurice T. James and Willis W. Wirth ¹

James (*in* Stone et al., 1965, "Catalog of the Diptera of America North of Mexico," Agric. Res. Serv. Handbook 276) listed *Hermetia aurata* Bellardi (with *H. a. eiseni* Townsend as a subspecies and *H. chrysopila* Loew as a synonym), as a single variable species with wide geographic distribution in the southwestern United States and Mexico. Though some spade work that had been done by Wirth indicated that the three forms were specifically distinct and, in addition, several undescribed taxa were involved, more time and specimens were necessary to resolve the problem. The present study is built upon this foundation and includes a preliminary key plus additional material that has been assembled from a number of collections: the United States National Museum, the American Museum of Natural History, the California Academy of Sciences, Cornell University, Ohio State University, Michigan State University, the University of Kansas, Kansas State University, Washington

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State University, Oregon State University, the University of Arizona, and the University of California at Berkeley, Davis, and Riverside. Holotypes and allotypes, unless otherwise stated, are in the United States National Museum.

Three names are currently available for species-level taxa in this complex, namely *H. aurata* Bellardi (type-locality Morelia, Michoacan, Mexico), *H. chrysopila* Loew (described from specimens from Texas in the Belfrage collection), and *H. eiseni* Townsend (described from the Eisen collection from southern Baja California, Mexico). These three are herein recognized as distinct species, contrary to the usage in the "Catalog." The seven new species described below, with two exceptions, show very close affinities with the above three and constitute a natural group of species that apparently is restricted geographically to Mexico and the southwestern United States. The two exceptions, *Hermetia anthidium* and *H. conjuncta*, can readily be added to the group by some extension of its definition; however, they undoubtedly are more remote from the complex that forms the core of the group. The eight species of the core complex, or at least seven of them, can be interpreted as a superspecies. Five of these—namely, *H. chrysopila*, *H. aurata*, *H. eiseni*, *H. ryckmani*, and *H. melanderi* (figs. 11, 12)—are completely allopatric in respect to one another. The distribution of *H. chrysopila* (fig. 11) is eastward from the front range of the Rocky Mountains and the Sierra Madre Oriental to the 95th meridian and between parallels 23° and 41° N; *H. melanderi* extends, west of the Rocky Mountains and Sierra Madre Occidental, from southeastern Arizona and southwestern New Mexico to northern Sinaloa; *H. ryckmani* occurs only in western Arizona and southern California; and *H. eiseni* occurs only in southern Baja California. Of the other three species, *H. nigricornis* and *H. subpellucida* are partially sympatric with each other and with *H. melanderi* but essentially allopatric with the other species, *H. subpellucida* extending only slightly into the range of *H. aurata*. The one known locality for *H. impressa* falls within the range of *H. aurata*. Male genitalia in the core complex are very homogeneous throughout; there is some variation from species to species, but variation within a species also occurs. It is possible that *H. impressa* should be excluded from the core complex, but its males, and consequently the male genitalia, are unknown.

Members of the group can be recognized readily by the combination of densely pilose eyes and the profile of the face: from the front view, the face is regularly rounded below; from the lateral view, it does not project conelike below the level of the eyes as is the case in most of the genus. *Hermetia anthidium* (fig. 1) is somewhat exceptional in

this respect although the projection of its face can hardly be considered conelike. *Hermetia hunteri* Coquillett has a rounded face but bare eyes, and its form, not to mention its genitalia, is so unlike members of the *H. aurata* group that it could not by any means be confused with them.

Other characteristics of the group are as follows: The frontal callus is represented by a bare, more or less triangular, area adjacent to each eye; above this, adjacent to the eye, the area is moderately to deeply depressed, at least lightly rugulose, usually deeply sculptured with irregular prominences or longitudinal carinulae (this term being applied to distinct and more or less sharply keeled ridges running lengthwise of the frons); between these areas and in front of the ocellar triangle there is a bulbous prominence, which we are designating the "ante-ocellar tubercle"; there is a small, flat callus, sometimes obscure or virtually wanting, just above the antennal bases (the supra-antennal callus). The wings are largely or wholly clouded, frequently with a yellow area, contrasting with the generally brownish clouding, extending at least across the stigma; vein R_{2+3} arises beyond cross-vein r-m: the wing is largely set with microtrichia, the basal part and at least a narrow anterior margin of cell 1st A being bare. The abdomen is ovate or elongated ovate, the sides of the second to fourth segments parallel, except in *H. anthidium* in which the abdomen is more rounded. The vestiture of the abdomen tends to form dense areas of long, appressed yellow to golden pile, particularly on the terminal terga; this pile is especially dense in such species as *H. aurata*. The genitalia (fig. 8) present a moderately uniform pattern with some variations. What we interpret to be the dististyle has migrated ventrad and laterad of the basistyle so as to appear like a lower lobe of the latter; from side view, in this group, we see chiefly the basistyle, with the dististyle ending far before the apex of the basistyle and appearing as a small angulated or rounded ventral projection (figs. 3-6).

Key to Species of the *Hermetia aurata* Group

1. Vanellike style of female flagellum (male unknown) acuminate, white at apex; abdomen short and robust, not much longer than wide, and black with narrow interrupted tegumentary yellow apical bands on terga 2 to 4.
anthidium James, new species
Vanellike style of female flagellum rounded at apex, sometimes acute but never acuminate and never white tipped; abdomen 1.5 to more than 2 times as long as wide and without tegumentary pale markings beyond the second tergum though the general coloration of the abdomen may be reddish. 2
2. Tibiae entirely yellowish, at most somewhat orange or orange yellow on apical third to half 3
- Hind tibia, at least, distinctly blackened or brownish black on apical third or more 5

3. Wing entirely grayish; mesonotal pile whitish in male to yellow or golden in female, uniformly colored, at most with a poorly defined presutural vitta that may be set off feebly by a very small amount of obscure, blackish pile; flagellum of antenna wholly black to base.

nigricornis James and Wirth, new species

Wing yellowish on part or all of anterior half; tibiae wholly yellow; antenna with base of flagellum distinctly yellow or, if entirely black, a distinct presutural vitta of golden pile present 4

4. Brassy pile of sublateral areas of second abdominal tergum forming a broad triangular area reaching almost to base of tergum and clearly visible as abdomen is rotated under light of varying incidence . . **chrysopila** Loew

Brassy pile of sublateral areas of second abdominal tergum limited to the posterior margin **melanderi** James and Wirth, new species

5. Second abdominal sternum largely or wholly pale in contrast to preceding and following sterna, second tergum likewise largely pale or with two translucent spots 6

Second abdominal sternum largely concolorous with preceding and following sterna and not translucent; second tergum with at most indefinite, non-translucent pale areas 7

6. Abdomen more than twice as long as wide; second abdominal tergum with a pair of translucent spots, separated in the female but sometimes fused in the male; all tibiae largely black; mesonotal pile uniformly pale yellowish, without a presutural vitta; guards of aedeagus united ventrally, not terminating in setulae **conjuncta** James, new species

Abdomen distinctly less than twice as long as wide; second abdominal tergum with a broad, trapezoidal, semipellucid area taking in a large part of the segment; only the hind tibia black or blackish apically; mesonotum with a median presutural vitta, usually set off by adjacent vittae of short, black pile; guards of aedeagus of the usual *chrysopila* group type, well separated ventrally and terminating in setulae.

subpellucida James and Wirth, new species

7. Frons with a prominent inverted U-shaped impression, particularly prominent at the anterior extremes of its arms just above the frontal callus, and shallowest where it crosses between the ocellar triangle and the ante-ocellar tubercle; all tibiae largely black . . . **impressa** James, new species

Frons laterad of ante-ocellar tubercle concave transversely but not deeply impressed, this concave area not extending conspicuously above the ante-ocellar tubercle; blackening of tibiae confined to apical half or third . . . 8

8. Scutellum yellow on posterior margin only; abdominal integument blackish, at most becoming reddish on parts of the terminal terga; dorsal abdominal pile dense, particularly in male, that of terminal two terga at least almost completely covering background **aurata** Bellardi

Scutellum with distal half yellow; abdominal integument in male usually largely reddish or reddish brown on at least terga 3 to 5, less extensively or not at all reddish to reddish brown in female; abdominal pile less dense, the terminal terga by no means completely with background concealed . . . 9

9. Mesonotal pile wholly yellowish to whitish, the presutural vitta not at all differentiated in the female, but poorly differentiated in the male.

eiseni Townsend

Mesonotal pile yellow to golden, the presutural vitta well differentiated in both sexes and set apart from the other mesonotal pile by a vitta of black, pile on each side **ryckmani** James and Wirth, new species

Hermetia anthidium James, new species

FIGURE 1

Female: Head black in ground color, copiously marked with yellow as follows: a rounded, slightly elevated spot on each side of the ocellar triangle and extending from the ocellar triangle to the eye margin; a transverse area including the two segments of the frontal callus and connecting them (but not as a callus), thence continuing as a narrow ocular orbit on each side below the eye; and a broader median area connecting broadly with the supra-antennal band and extending ventrad around the antennal bases and over the midfacies to the oral margin, becoming more whitish on the facial prominence; these yellow facial and supra-antennal areas isolate a broad, black, shining area on each side that extends from just above the antenna to the oral margin. Some short, stiff black pile on the ocellar triangle, that of head otherwise longer and yellow, rather dense. Ante-ocular tubercle prominent, domelike, shining but with finely impressed, narrow striations running transversely in the median line and concentrically on the sides; area on each side above frontal callus punctate and only slightly rugulose and without distinct carinulae. Supra-antennal callus obscure, almost obsolete. Head measurements: Head width 3.25 mm, height 2.00 mm; frons at vertex 0.83 mm, at callus 1.33 mm; distance between eyes at oral margin 1.08 mm. Pile of eyes rather short, yellow, that above appearing black in some lights. Antenna as in figure 1; first and second segments yellow, the first blackish above, with black pile; flagellum brownish black, the style black, its acuminate tip broadly white and sharply contrasting with the rest of the flagellum; longitudinal groove of flagellum more conspicuous from inner but also quite apparent from outer surface. Proboscis yellow, the more strongly sclerotized areas black; pile yellow.

Ground color of thorax mostly black; humerus, postalar callus, a prealar spot on each mesopleuron, and apical two-fifths of scutellum yellow; dorsal pile black except a median presutural vitta, a triangular area on each side of it and reaching the humerus anteriorly, a transverse area just before the suture and reaching medially almost to the apex of the triangle on each side, a prescutellar band reaching from one postalar callus to the other, and a narrow band along the margin of the black area of the scutellum, golden; pile of metanotum black; that of pleura largely black; that of propleura and prosternum, posterior part of mesopleuron, most of sternopleuron, upper part of metapleuron, and apex of squama whitish. Coxae, trochanters and femora except extreme tips black, mostly black haired; tibiae and tarsi pale yellow, becoming whitish at bases of tibiae and on tarsi, white haired; apical two tarsomeres on all legs yellow with yellow hair,

claws becoming brownish at tips. Squamae dark brown. Wing infumated, more heavily so anteriorly than posteriorly; a broad longitudinal subhyaline area taking up all of second basal cell except its apex, the anterobasal part of the anal cell, and the bases of the fourth to second posterior cells, this area being devoid of microtrichia; the infumation posterior to and apicad of this area apparently due wholly to microtrichia and consequently not so intense as that anterior to it, in which the membrane is also infumated.

Abdomen short, slightly longer than wide (3.90 mm and 2.75 mm respectively); black, narrow apices of terga 2 to 5 and of sterna 1, 2, and 5, also narrow base of sternum 2, yellow, the bands tegumentary, those on terga 2 to 4 broadly interrupted medially; pile of first tergum and median part of second black, otherwise yellowish to brownish yellow, scattered and semi-erect on sterna 1 and 2, otherwise appressed. Ovipositor brown, terminal segment and cerci yellow. Length 7 mm.

Holotype: ♀, Barro Colorado Island, C.Z., Mar. 27, 1963, malaise trap, C. W. and M. E. Rettenmeyer; in the collection of Kansas State University.

The specific name was suggested by the resemblance to a megachilid bee of the genus *Anthidium*.

***Hermetia nigricornis* James and Wirth, new species**

FIGURE 4

Male: Head black; vertex, a pair of spots on each side of the ocellar triangle and usually confluent with the vertex, frontal callus, an indefinite area at antennal bases, and sides of face yellow, these areas usually more extensive than in the other species of this group. Ante-ocular tubercle moderately prominent, shining, without striations; area above frontal callus rugulose but at most with only poorly defined carinulae; supra-antennal callus variable, usually small and poorly defined. Pile of head whitish. First and second antennal segments brown, the latter becoming brownish yellow, particularly at its apex; flagellum black to blackish to its base. Thorax black, humeri, postalar callus, and apical half of scutellum yellow; all thoracic pile uniformly whitish; no presutural vitta. Femora blackish; tibiae and tarsi wholly yellow, apical half of each orange yellow. Wing entirely grayish, apex and posterior half somewhat darker. Halteres yellow. Abdomen uniformly black but with a tendency to become reddish brown, particularly apically; second sternum with a transverse basal and a much smaller transverse apical pale area, these sometimes connected medially by a narrow vitta; pile of abdomen whitish dorsally and ventrally, some black pile, the exact amount variable, at base of first tergum; tergal pile moderately dense. Geni-

talia orange yellow; basistyle and dististyle as in figure 4. Length 8–11 mm.

Female: Similar to the male, but the dorsal pile is slightly to distinctly more yellow; the presutural vitta may be poorly defined or, as in the male, absent; most of the pile of the anterior half of the postscutum is short and black. In one paratype the mesonotal pile is golden and the presutural vitta, though feeble, is somewhat set apart by a few black hairs arranged so as to suggest lateral vittae.

Holotype: ♂, Florence Junction, Ariz., Apr. 21, 1935, F. H. Parker, Melander Collection; USNM type no. 69,103. Allotype: ♀, with puparium, Saguaro National Monument, Ariz., ex *Echinocereus*, Nov. 8, 1957, S. Alcorn; University of Arizona collection.

Paratypes: 2 ♂♂, same data as holotype. ARIZONA: 1 ♀, Pinal Mts., Aug. 4, 1939, F. H. Parker; 1 ♂, base of Pinal Mts., May 22, 1938, D. K. Duncan; 1 ♂, Ray, Apr. 18, 1957, F. H. Parker; 1 ♂, 15 miles south of Ray, May 4, 1961, R. H. and E. M. Painter; 2 ♂♂, Globe, Apr. 7, 1938, F. H. Parker, and August, D. K. Duncan; 1 ♂, Organpipe Monument, Alamo Canyon, Apr. 22, 1948, J. L. Sperry; 2 ♂♂ Sabino Canyon, Santa Catalina Mts., Apr. 6, 1955, F. G. Werner; 1 ♂, Oracle, Apr. 15, 1937, G. P. Engelhardt; 1 ♂, "Catal Spgs.," Apr. 14, 1898, E. A. Schwarz; 3 ♂♂, San Carlos Lake, April, D. K. Duncan; 1 ♂, Black Dyke Prospect, Sierritas, July 26–29, 1916, NEW MEXICO: 1 ♂, Jemez Springs, July 1, 1941, R. H. Beamer; 4 ♂♂, 1 ♀, Tajique, June 25, 1941, E. L. Todd; 1 ♂, Sandia Mts., May 22, 1948, L. S. Gordon; 1 ♂, "Monzano" [Manzano?], June 26, 1941, R. H. Beamer. TEXAS: 1 ♂, Boy Scout camp, south of Toyahvale, May 2, 1961, Killiam Roever. UTAH: 1 ♂, Beaver Creek Hills, Beaver Co.; 1 ♂, Beaver Valley. COLORADO: 1 ♂, Granite Peaks Camp, Bayfield; 1 ♂, Great Sand Dunes, Alamosa, Aug. 1, 1950, B. Rotger.

Hermetia chrysopila Loew

FIGURES 9, 11

Hermetia chrysopila Loew, 1872, Berliner Ent. Zeitschr., vol. 16, p. 56 (Centuria 10, no. 11).

Hermetia aurata Bellardi.—James, 1965, in Stone et al., Catalog of the Diptera of America north of Mexico, p. 304, partim [not Bellardi, 1859].

This species remains a variable one even though our concept of it is more restricted than that indicated in most of the literature. The vertex, except the ocellar triangle, is typically wholly yellow (sometimes a sordid or brownish yellow); the areas laterad of the ocellar triangle are elevated, somewhat tubercle-like, with fine lengthwise striations; the areas above the frontal callus are rugulose with two or three low but sharp irregular carinulae. The supra-antennal callus

is small but distinct and black. The mesonotum is mostly or wholly yellow to golden pilose, with a prominent median vitta, visible clearly without magnification, extending from the suture to a polished area on the anterior margin; the pile adjacent to this vitta is usually a pale yellow although in some specimens, particularly from the southern part of the range of the species (Texas and Mexico), the vitta is margined on each side by a distinct vitta of black hairs. The distributional pattern cannot, however, be interpreted as defining a subspecies since no exact geographic area is defined by it; indeed, both types occur in a series collected by R. H. and L. D. Beamer at Giddings, Tex. A tendency toward reddening of the abdomen in the male, particularly in Texan and Mexican specimens, is noticeable. The larger part of the abdomen is clothed with long, curved, appressed yellow to golden pile; this becomes less conspicuous in the more southern specimens. The male genitalia are similar to those of *H. melanderi* but the dististyle (fig. 9) has a different shape; its inner apical margin is always concave, sometimes deeply so, with a shoulder although the exact outline is subject to some variation; from lateral view the apex of the dististyle is angular in apical outline, forming an acute or right angle.

Geographical distribution (fig. 11): most or all of Kansas, except possibly the extreme eastern part, westward through Colorado to the front range of the Rocky Mountains and southward across Oklahoma and central Texas into northeastern Mexico. We have records from the following Mexican localities: Coahuila: Hermanas; Nuevo Leon: Monterrey, Vallecillo; Tamaulipas: Ciudad Victoria.

***Hermetia melanderi* James and Wirth, new species**

FIGURES 6, 8, 11

Close to *H. chrysopila*, from which it may best be differentiated by the more limited amount of golden pile on the posterior margin of the second tergum; viewed from behind or medially, this pile is limited to a narrow patch, somewhat broadened sublaterally, on each side of the median line but separated from the whitish anterolateral pile of this tergum by a broad area of black pile, whereas in *H. chrysopila* these areas of golden pile extend in the form of a broad triangle almost to the base of the tergum. *Hermetia melanderi* can be separated from *H. chrysopila*, with exceptions as noted under the discussion of that species, by the more extensive black pile of the mesonotum, which includes a narrow vitta on each side of and isolating the presutural golden vitta and which takes in the anterior two-thirds of the postscutum. Also, in *H. melanderi* the eye pilosity is denser and longer than in *H. chrysopila*.

Male, female: Head, thorax and abdomen predominantly black. Yellow markings of head variable but basically consisting of a spot on each side of the ocellar triangle, the divided frontal callus, an indefinite area at base of antennae, and narrow facial orbits; anteo-cellular tubercle prominent; area above frontal callus coarsely rugulose and with a single broad carinula or with one more prominent than the remaining one or two; supra-antennal callus more prominent than in *H. chrysopila*, somewhat elevated. Humeri, postalar callus, and about apical half of scutellum yellow; halteres yellow; apices of femora, all of tibiae and tarsi, yellow, the apical half of each tibia becoming more orange yellow. Terga 1 and 2 mostly with short black pile; a fringe of yellow pile, usually interrupted medially, on tergum 1; an anterolateral triangle of thin yellowish pile and the patch of golden pile as described on tergum 2; remaining terga with conspicuous long appressed golden pile except for a sublateral triangle of black pile on each side of tergum 3 and a similar but less conspicuous triangle on tergum 4; venter white pilose. Male genitalia as in figures 6, 8. Length 9–12 mm.

Holotype: ♂, Globe, Ariz., Apr. 11, 1935, F. H. Parker; Melander Collection; USNM type no. 69,104. Allotype: ♀, same data, but May 1, 1935.

Paratypes: ARIZONA: 16 ♂♂, same data as type but Apr. 6, 7, and 8, 1935, and Apr. 7, 21, and May 1, 1938; 1 ♂, Globe, April, D. K. Duncan; 3 ♂♂, 3 ♀♀, Baboquivari Mts., Elkhorn Ranch, 4500', Apr. 20, 1961, and Brown Canyon, Apr. 7, 1961, M. L. Noller, J. C. Bequaert; 2 ♂♂, 5 ♀♀, Baboquivari Mts., April, D. K. Duncan, Apr. 27, 1947, A. L. Melander, Apr. 28, 1935, F. H. Parker, and Apr. 4–19, 1937, W. Benedict; 2 ♂♂, 1 ♀, Madrona Ranger Station, Ricon Mts., May 15, 1964, at mud and water, M. L. Noller, J. C. Bequaert, M. Elton, M. Nurein, F. G. Werner, and May 22, 1964, Bequaert and Noller; 1 ♂, 1 ♀, Sabino Canyon, Santa Catalina Mts., Apr. 5 and 30, 1955, G. D. Butler; 1 ♂, Sabino Basin, Santa Catalina Mts., July 8–20, 1916; 3 ♀♀, Santa Catalina Mts., April, D. K. Duncan, and Apr. 9, 1955, Butler and Werner; 1 ♀, Canada del Oro, north of Santa Catalina Mts., Apr. 17, 1964, M. L. Noller, J. Burger, J. C. Bequaert, and F. G. Werner; 1 ♀, 10 miles north of Tucson, Apr. 21, 1957; 1 ♀, Madera Canyon, Santa Cruz Co., 4880', July 15, 1963, V. L. Vesterby; 2 ♀♀, Pinal Mts., May 9, 1937 and May 6, 1940, F. H. Parker; 2 ♀♀, Portal, Cochise Co., June 28 and July 1, 1963, A. Laske; 1 ♀, Molino Basin, Mt. Lemmon, May 5, 1953, A. and H. Dietrich. NEW MEXICO: 1 ♀, Byer Spring, Florida Mts., 5000'. MEXICO: SINALOA: 1 ♂, 13 miles north of Culican, Mar. 17, 1962, F. D. Parker.

Hermetia conjuncta James, new species

FIGURES 7, 10

This species, particularly in the female, bears a close superficial resemblance to a rather small *H. illucens* (L.); it is distinctly more elongated than other members of the *H. aurata* group. The male genitalia are of the *H. chrysopila* type but differ from those of other known members of the group in that the guards of the aedeagus are fused and do not terminate in distinct setulae. A somewhat disturbing peculiarity in this species is the variability in the color of the pile, but this seems to indicate merely a certain amount of genetic instability within the species.

Male: Head black; yellow areas more reduced than in other members of the group and limited to the small frontal callus, a rounded spot on each side of the ocellar triangle, and a large transverse spot, behind the ocellar triangle and not reaching the eye, on the posterior part of the vertex and upper part of the occiput; face entirely black or with its prominence yellowish medially. Ante-ocellar tubercle glabrous, as large but not as prominent as in other members of the group; supra-antennal callus distinct, tubercle-like; area above frontal callus rugulose but without distinct carinulae. Pile of head yellow to whitish, tending to deeper yellow on lower face and on vertex, and in those areas with a variable, sometimes a considerable, amount, of black to blackish pile intermixed; eyes with long, dense, white to pale yellow pile. Antennae black, the second segment brownish to reddish yellow. Proboscis black. Thorax black, humeri, postalar callus, and sometimes extreme apical margin of scutellum brown; mesonotal pile uniformly reddish brown, no differentiated presutural vitta; a dense area of yellowish and whitish pile at apex of scutellum. Basal third of hind tibia yellow, femora and tibiae otherwise black except narrowly and indefinitely at knees. Tarsi pale yellow to clear yellow, becoming somewhat darker apically. Wing (fig. 10) gray but with a yellow area extending through second basal cell, across and including the entire discal cell, to the wing margin from stigma to vein R_4 ; area bare of microtrichia more extensive than usual for the group, vein Cu_2 being broadly bordered on both sides through much of the fifth posterior and first anal cells by the microtrichia-free area. Halteres orange, base of stalk more brownish. Abdomen black at base, at least the fifth and usually the fourth and part of the third segment, sometimes more, becoming reddish brown, more extensively so ventrally than dorsally; second segment translucent white on most of the sternum and on two large rectangular spots on the tergum, which are either separated from each other by a narrow black line or totally fused. Pile whitish at base and laterally

except that the parted pile of the first tergum may vary through yellow to golden and the translucent areas may bear some short black in addition to the pale hairs; pile of terga 3 to 5 dense; reddish brown, that of sterna 3 to 5 of variable color, sometimes largely black. Genitalia (fig. 7) reddish brown; dististyle concave on inner apical surface with several microdenticles, which are not visible from lateral profile. Length 10–11 mm.

Female: Closely similar to the male; pile of head more extensively white; thorax entirely black. Microtrichia-free area of wing much more extensive, taking in almost all the first anal cell, about half the second anal, and the upper basal part of the fifth posterior cell. Abdomen except translucent areas wholly black. Color of abdominal pile variable; in the allotype that of terga 2 and 3 and of sterna 4 and 5 short, black. Length 11–14 mm.

Holotype: ♂, Isthmus of Tehuantepec, Sumichrast, Mexico; USNM type no. 69,105. Allotype: Yautepec, Morelos, Mexico, July 31, 1963, F. D. Parker and L. A. Stange; University of California, Davis.

Paratypes: MEXICO: 3 ♂♂, same data as holotype; 2 ♂♂, same data as allotype. MORELOS: 1 ♂, Hujintlan, Aug. 22, 1956, R. and K. Dreisbach; 1 ♂, Lobo Canyon, 13 miles east of Cuernavaca, 3400', Aug. 15, 1962, R. H. and E. M. Painter; 1 ♀, 5 miles east of Cuernavaca, July 16, 1963, Parker and Stange.

***Hermetia subpellucida* James and Wirth, new species**

The coloration of the second abdominal segment will readily distinguish this species from all others in the complex except *H. conjuncta*, which would not be easily confused with *H. subpellucida* because of its *H. illucens*-like appearance and its much more slender abdomen. An occasional specimen of another species, for example a female *H. eiseni* or a slightly teneral *H. chrysopila*, may have a suggestion at least of a pair of pale tergal spots, but these are never subpellucid or transparent and do not involve the sternum, as do the subpellucid areas in *H. subpellucida* and *H. conjuncta*.

Male, female: Head black, frontal callus, narrow facial orbits, a pair of spots on each side of the ocellar triangle, and vertex, as usual, yellow to yellowish and, again, as usual for the group, subject to considerable variation as to the extent of the markings; in most specimens the spots beside the ocellar triangle are continuous with the vertex, forming one continuous area without indication of any division. Ante-ocular tubercles smooth, without striations; area above frontal callus rugose with one to three, usually two or three, well-defined carinulae. Supra-antennal callus usually distinct but small, sometimes obscure. Mesonotum with a median presutural

vitta and a broad transverse prescutellar band of golden appressed pile; otherwise yellow pilose except usually, but not always, a band of black pile on each side of the median presutural vitta. Legs yellowish; femora blackish; hind tibia dark brown to black on apical third to fourth, at least externally. Wing yellow on about anterior half, including entire discal cell and extending beyond apex of vein R_5 ; posterior half brown; area devoid of microtrichia, limited, except at base, to anterior margin of anal cell. Abdomen black basally; tergum 2 largely pellucid yellow, only the broad lateral margins, broader anteriorly than posteriorly, black, the pellucid area consequently in the form of a trapezoid, this area sometimes darkened medially but not divided into two spots, as in *H. illucens*; sternum 2 wholly pellucid yellow or with only the lateral margins black; abdomen beyond second segment variable, largely or wholly black or blackish in the female, usually largely or wholly reddish, at least reddish on apical segments, in the male. Abdominal pile largely as in *H. chrysopila* but the golden pile in general less conspicuous; also terga 3 and 4, and to a lesser extent 5, with poorly defined sublateral triangles of black pile; a narrow transverse band of black pile at base of third tergum. Dististyle convex on its lower apical margin; from lateral view, it is rounded apically. Length 9–12 mm.

Holotype: ♂, Globe, Ariz., Sept. 9, 1941, F. H. Parker; Melander Collection; USNM type no. 69,016. Allotype: ♀, Skeleton Canyon, 6 miles southeast of Apache, Cochise Co., Ariz., Sept. 1, 1958, P. D. Hurd; University of California (California Insect Survey), Berkeley.

Paratypes: ARIZONA: 2 ♂♂, Globe, July 23, 1944, F. H. Parker, 3600', mesquite, cholla, Aug. 6–9, 1948, W. Nutting; 1 ♀, 3 miles east of Portal, Cochise Co., Aug. 15, 1965, M. E. Erwin; 3 ♂♂, 17 miles east of Douglas, Cochise Co., Aug. 8, 1958, P. Opler, R. M. Bohart; 1 ♂, Leslie Canyon, Douglas, Aug. 16, 1931, Virginia Reed; 1 ♂, Cochise Stronghold, Sept. 6, 1960, L. A. Stange; 1 ♀, Molino Basin, Pima Co., Aug. 30, 1951, C. D. MacNeill; 1 ♀, Madera Canyon, Santa Cruz Co., 4800', Aug. 5, 1963, V. L. Vesterby; 4 ♂♂, Baboquivari Mts., F. H. Snow, and July 19, 1950, L. D. Beamer, and July 18, 1950, J. Arnold; 1 ♂, Brown's Canyon, Baboquivari Mts., Aug. 18, 1955, F. G. Werner, G. D. Butler; 4 ♂♂, Santa Rita Mts., July 10, 1950, R. H. Beamer, and July 26, 1925; 1 ♂, Santa Rita Ranger Station, Pima Co., Aug. 8, 1957, C. W. O'Brien; 1 ♂, Florida Canyon, Santa Rita Range Refuge, Pima Co., July 20, 1959, G. A. Samuelson; 2 ♂♂, Safford, Sept. 6, 1955, R. W. Dawson; 3 ♂♂, Sabino Canyon, Santa Catalina Mts., Aug. 14, 1950, R. A. Beal, and Aug. 7, 1953, G. D. Butler; 1 ♀, Santa Catalina Mts., Aug. 22, 1954, G. D. Butler; 1 ♂, Cave Creek Ranch, Chiricahua Mts., 5000', Aug. 3, 1965, G. R. Balmer; 2 ♀♀, Ramsey Canyon, Huachuca Mts., Sept. 6, 1956, F. G.

Werner, G. D. Butler; 9 ♂♂, 2 ♀♀, Tucson, Aug. 15, 17, 23, and 26, 1955 (one pair in copula), G. D. Butler, and Aug. 16, 1940, D. J. and J. N. Knull. NEW MEXICO: 2 ♂♂, Rodeo, Aug. 5, 1955, R. R. Dreisbach, and Aug. 7, 1958, R. E. Rice; 1 ♀, 3 ♂♂, 18 miles north of Rodeo, Aug. 25, 1958, P. M. Marsh, R. M. Bohart; 1 ♂, 19 miles north of Rodeo, Aug. 9, 1965, E. M. Brown. MEXICO: BAJA CALIFORNIA: 1 ♂, 15 miles south of Santo Domingo, Oct. 4, 1941, E. S. Ross, R. M. Bohart. SONORA: 2 ♂♂, 10 miles west of Alamos, July 21, 1954, M. Cazier, W. Gertsch, Bradts. SINALOA: 1 ♂, 30.5 miles north of Los Mochis, Aug. 24, 1964, M. E. Erwin; 1 ♂, 8 miles south of Elota, July 2, 1963. NAYARIT: 1 ♂, Ahuacatlan, July 18–22, 1951, on flowers of *Donnellsmithia hintoni* M. and C., P. D. Hurd.

It is noteworthy that this is a late summer and fall species, whereas the two that are largely sympatric with it, *H. melanderi* and *H. nigricornis*, are spring and early summer species.

Hermetia impressa James, new species

FIGURE 2

Differs from all other known species of the group in the deeply impressed sculpturing of the frons, as described below, and the divided ante-ocular tubercle.

Male: Head black; a pair of spots posteriorly on the vertex, the lower facial orbits, frontal callus, and a small margin above each antennal base, yellow; a brownish spot below the ante-ocular tubercle and, in the paratype, an indefinite spot of similar color on each side of the anterior ocellus. Frons deeply excavated by a broad trough or furrow beginning on each side between the triangle of the frontal callus and the ante-ocular tubercle and continuing above the latter in the form of an inverted U, the ocellar triangle being broadly separated from the ante-ocular tubercle by this trough; the usual area above the frontal callus with two strong glabrous carinulae and a weaker one between them, all running longitudinally of the frons; ante-ocular tubercle glabrous, divided above by two transverse furrows, the lower the more prominent; supra-antennal callus distinct and glabrous; pile of head white. Eyes with short, dense black pile. Basal two antennal segments brownish yellow; flagellum dark brown, style black and black pilose. Proboscis brownish black with white pile. Thorax mostly black; middle of pronotum, humeri, and apical third of scutellum yellow; mesonotum with mostly golden pile, the presutural vitta and transverse prescutellar band well marked; a triangular patch above each wing base, a stripe to each side of the mesonotal vitta and turning J-like laterad so as partially to define an outer pair of vittae, and basal third of scutellum, black pilose;

sides of mesonotum before the suture and extending somewhat inward at the suture, as well as all pleural areas, white pilose. Anterior half of wing yellow to apex of discal cell and vein R_4 , otherwise brown; microtrichia-free area in anal cell very narrow. Halteres yellow. Apical half of fore- and hind tibiae and apical two-thirds of middle tibia black. Abdomen mostly black, the apex becoming reddish brown; terga 4 and 5 and sternum 5 mainly reddish brown, with a black median triangle at base of tergum 4 and a black triangle on each side; pile of first and second terga black except for a large sub-lateral triangle of golden pile on each side of the second as in *H. chrysopila*; that of terga 3-5 dense, golden except a median and a lateral triangle on each side of each tergum, those on the fifth definitely the smallest, those on the third and fourth relatively large; venter white pilose. Genitalia yellow; dististyle prominent from lateral view, apex almost rectangular but slightly acute and sharp pointed. Length 8-9 mm.

Holotype: ♂, 6 miles south of Temixco, Morelos, Mexico, July 16, 1963, F. R. Parker, L. A. Stange; University of California, Davis.

Paratype: ♂, same data.

Hermetia aurata Bellardi

FIGURES 3, 12

Hermetia aurata Bellardi, 1859, Saggio di ditterologia messicana, vol. I, p. 27.—Williston, 1900, Diptera, in Godman and Salvin, Biologia Centrali-Americana, p. 240.—James, in Stone et al., Catalog of the Diptera of America north of Mexico, p. 304, partim.

Though we have not seen Bellardi's types, we feel confident that our interpretation of this species is correct. The type-locality is Morelia, Michoacan, Mexico, which fits well into the known distributional pattern of this species but not into any other member of the group with which it might be confused. As Williston points out, Bellardi makes no mention of a yellow border to the scutellum; specimens that we interpret to be *H. aurata* have the scutellum wholly black or with at most a very narrow yellow border, whereas in all other species of the complex the yellow area is prominent and may be extended to cover the apical half of the scutellum.

The supra-antennal callus is poorly developed or vestigial; the area above the frontal callus is rugulose, with two or sometimes only one well-marked carinulae. The thoracic pile is mostly yellow to golden and relatively inconspicuous except for the presutural median vitta, which is set apart by a vitta of black pile on each side, and a transverse prescutellar band; the hind tibia is black on the apical third to half, except at its extreme tip; and the others are reddish brown to dark brown or blackish on the same area; the pile of the ter-

minial abdominal terga is dense and golden. The abdomen usually is wholly black; sometimes, in the males, the terminal segment may become reddish brown, and occasionally a pair of pale, but not translucent, spots may appear on the second tergum. The male genitalia are reddish yellow to reddish brown; the basistyle is robust; the dististyle, from ventral view, oval, its apex, when viewed laterally being rounded and projecting only very inconspicuously (fig. 3).

Geographic distribution (fig. 12): Southern Sinaloa (Elota, Mazatlan) to Durango and San Luis Potosi (Ciudad del Maiz) south to Oaxaca (Oaxaca, Camaron) and Guerrero (Amula, Venta de Zapilote, recorded by Williston, 1900). We have records from the following Mexican states within the above distributional area: Zacatecas, Aguascalientes, Nayarit, Guanajuato, Jalisco, Michoacan, Morelos, Veracruz, and Puebla. Seasonal records run from March to late October; however, this may merely reflect lack of collecting during the winter months.

Hermetia eiseni Townsend

FIGURE 11

Hermetia eiseni Townsend, 1895, Proc. California Acad. Sci., ser. 2, vol. 4, p. 594.

Hermetia aurata Bellardi.—Townsend, 1895, Proc. California Acad. Sci., ser. 2, vol. 4, p. 594 [not Bellardi].

Hermetia aurata ssp. *eiseni* Townsend.—James, in Stone et al., 1965, Catalog of the Diptera of America north of Mexico, p. 304, partim.

The supra-antennal callus is distinct and the area above the frontal callus rugulose, with two rather low carinulae; the mesonotum is wholly whitish to yellowish pilose, the pile thin except on the pre-scutellar band; a narrow presutural vitta is present in the male but absent in the female. The wing is brown with a yellow area extending the length of the second basal cell across the discal cell to the anterior margin and apex of vein R, so that both the posterior half of the wing and the anterior margin to the stigma remain brown; the differentiation in color is more marked in the female than in the male. The hind tibia is blackish to black on its apical third to half, the others reddish brown in the same area. The abdomen, at least when viewed from behind, is reddish brown in both sexes, the color more reddish in the male; however, the yellow pile of the abdomen is not as prominent as in *H. chrysopila*, more nearly comparable to *H. ryckmani*, and each tergum bears a broad transverse band of black pile, the yellow pile usually being limited to the extreme base and the apical half of the tergum. The male genitalia are similar to those of *H. ryckmani*.

So far as we know, this species is restricted to the southern part of Baja California (fig. 11), and other records in the literature pertain to other species. Townsend's types came from San Jose del Cabo and

El Taste; he also recorded a series of 34 specimens of *H. aurata* from the former locality. We have examined one male and four females from San Jose del Cabo and one male from El Taste, all Eisen Collection, also one female from Todos Santos, W. M. Mann. These seem to be conspecific, in spite of the differences between the sexes as indicated in the above description. Townsend made no mention of the sex of any of his specimens of either *H. eiseni* or what he took to be *H. aurata*; apparently he interpreted the males of the series as *H. aurata* and the females as the new species that he described as *H. eiseni*.

***Hermetia ryckmani* James and Wirth, new species**

FIGURES 5, 11

Hermetia aurata eiseni Townsend.—James, 1960, Bull. California Ins. Surv., vol. 6, p. 111; James, 1965, in Stone et al., Catalog of the Diptera of America North of Mexico, p. 304, partim.

Hermetia aurata Bellardi.—McFadden, 1967, Proc. U.S. Nat. Mus., vol. 121, no. 3569, p. 32.

Male: Head black, vertex, frontal callus, and sides of face, as usual, yellow; pile of head yellow, that of face more whitish, that of eyes dense, black above, brownish black below. Area above frontal callus, on each side, with two or three well-defined carinulae and rugulose, the sides of the front below these and the ante-ocellar tubercle distinctly but only moderately concave; ante-ocellar tubercle moderately prominent, smooth, sometimes with a few punctures above, not striate or but feebly longitudinally; supra-antennal callus small but distinct, glabrous. First two antennal segments and base of flagellum yellow, flagellum gradually becoming brownish yellow toward style, style black. Proboscis brown with white hairs. Thorax black, humeri and apical two-fifths to half of scutellum yellow. Presutural median vitta of mesonotum and transverse prescutellar band consisting of golden pile; a vitta of short pile to each side of presutural vitta and short pile of basal half of scutellum black; other thoracic pile yellow, tending to whitish or whitish yellow on the pleura. Anterior part of wing yellow to apex of vein R and including discal cell, the stigma, however, more brownish; area devoid of microtrichia limited to the basal cells and the narrow anterior part of cell 1st A. Tibiae and tarsi yellow, hind tibia black to blackish on apical fourth to third, fore- and midtibiae orange yellow on approximately apical half. Abdomen mostly reddish brown, first segment dorsally and ventrally and usually part of second black to blackish, rarely third segment somewhat blackish; a yellow transverse spot at base and a smaller one at apex of second sternum, usually connected by a median line. Pile of first and second terga black; a small apical fringe of golden pile

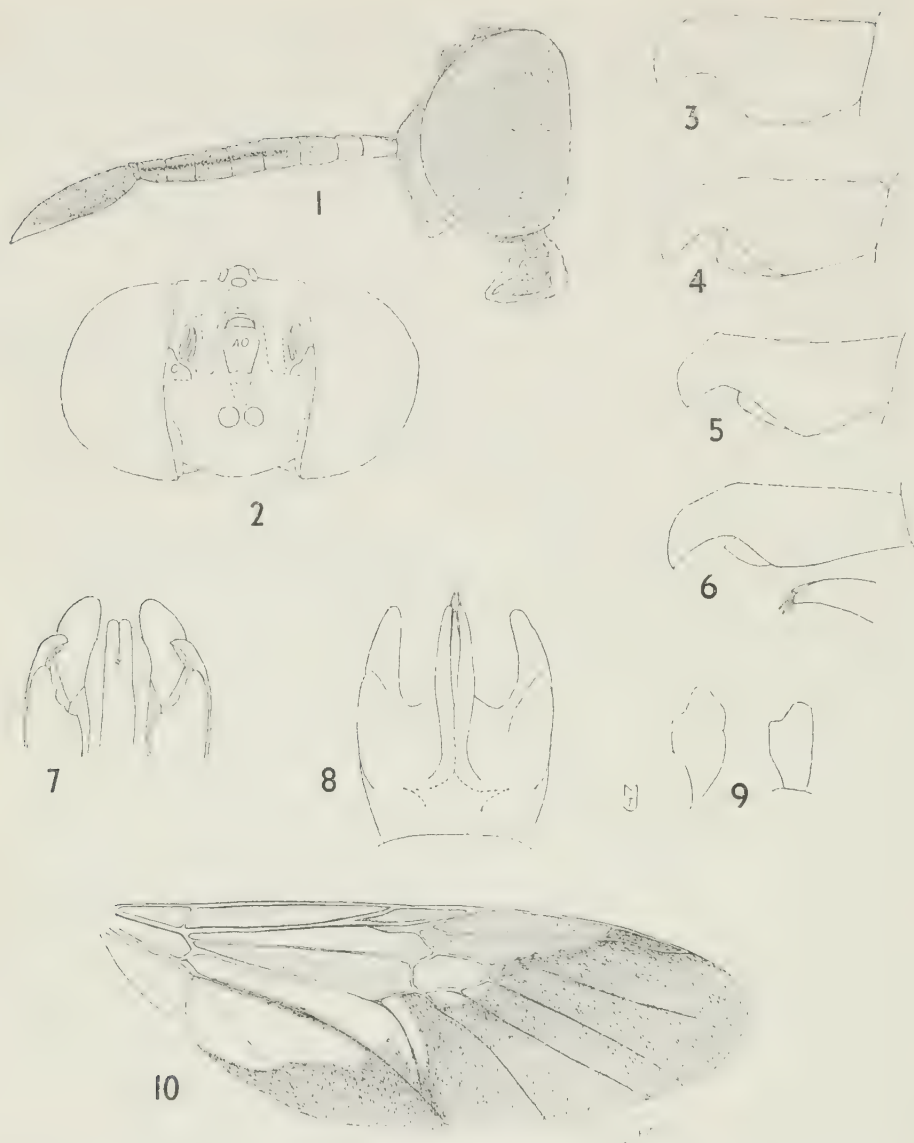
on first tergum and a small apical patch of similar pile on each side of the second; terga 3–5 mostly with appressed golden pile that is not nearly so conspicuous as in *H. aurata* and *H. chrysopila*, more nearly comparable to *H. eiseni*; a small sublateral triangle on each side and usually a small median patch of black hairs on terga 3 and 4; sterna with pale yellow pile. Genitalia reddish yellow; basistyle robust, dististyle similar to that of *H. melanderi* but rounded when viewed laterally (fig. 5). Length 11–14 mm.

Female: Differs chiefly from the male, other than sexually, in that the wing is brown throughout the costal and first basal cells, the yellowish area consequently forming a streak through the second basal, across the discal cell and to the apex of vein R, and in having the abdomen wholly black. The black of the hind tibia is more extensive, occupying as much as the apical half; even the darker areas of the other tibiae may be in part blackish.

Holotype: ♂, San Dimas Canyon, Pomona, Los Angeles Co., Calif., Nov. 23, 1960; host: *Opuntia occidentalis*, reared; R. E. Ryckman, L. E. Olsen; USNM type no. 69,107. Allotype: ♀, with puparium, same data, but Dec. 4.

Paratypes: CALIFORNIA: 5 ♂♂, 12 ♀♀, 5 with puparia, same data as holotype, but Nov. 23 and Dec. 4; 1 ♂, 3 ♀♀, same data, but Apr. 16, 1958, Ryckman, and June 10, July 24, and Aug. 1, 1958, Ryckman and J. P. Fonseca; 1 ♀, La Jolla, San Diego Co., June 18, 1963, J. Powell; 1 ♀, Santa Ana, Orange Co., Sept. 1, 1959, J. L. Bath; 1 ♀, 1 mile east of Del Mar, San Diego Co., July 17, 1963, E. I. Schlinger; 1 ♂, San Diego Co., bred from decaying cactus, Sept. 5, 1919, F. Psota; 2 ♂♂, San Diego Co., no date and Aug. 22, 1921; 2 ♂♂, Los Angeles, June 3, 4, 1909, F. C. Pratt, on *Opuntia*; 1 ♀, Los Angeles Co., July; 1 ♂, Los Angeles Co., June 18, Coquillett; 1 ♀, Filmore, June 27, 1937, B. E. White; 2 ♂♂, San Diego, July 13 and Aug. 20, 1921; 3 ♂♂, California, no other data. ARIZONA: 1 ♂, Congress, Aug. 13, 1939, K. Stager.

The puparia described by McFadden (1967, p. 32) were taken from the type series of this species.



FIGURES 1-10.—*Helmetia anthidium*: 1, head, lateral view (pile omitted except on eyes). *Helmetia impressa*: 2, head, front view, semidiagrammatic (AO=ante-ocular tubercle; C=frontal callus; the U-shaped trough between these structures and above the ante-ocular tubercle is set off by lines of short dashes). Male dististyle and basistyle, lateral view: 3, *Helmetia aurata*; 4, *H. nigricornis*; 5, *H. ryckmani*; 6, *H. melanderi* (and offset, apex of aedeagus). *Helmetia conjuncta*: 7, male genitalia, ventral view (basal part omitted, vestiture omitted). *Helmetia melanderi*: 8, male genitalia, ventral view (vestiture omitted). *Helmetia chrysopila*: 9, male dististyle, lateroventral (left) and ventral view (right). *Helmetia conjuncta*: 10, wing. (Fig. 10 drawn by Francoise Demogeot; others by M. T. James.)



FIGURE 11.—Geographic distribution of *Hermetia chrysopila* (open circles), *H. melanderi* (solid circles), *H. ryckmani* (solid squares), and *H. eiseni* (open squares). (Drawn by Francoise Demogeot.)



FIGURE 12.—Geographic distribution of *Hermetia aurata*. (Drawn by Francoise Demogeot.)

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3604

Revision of the Beetles Of Genus *Glyptoscelis* (Coleoptera: Chrysomelidae)

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In a paper on the Coleoptera of Fort Tejon, Calif. (Proc. Acad. Nat. Sci. Philadelphia, vol. 9, p. 81, 1859), LeConte briefly described the genus *Glyptoscelis* as follows: "The genus *Glyptoscelis* (Chevrolat) [Dejean Catalogue, 3rd ed., p. 438, nomen nudum, 1837] is distinguished from the other genera allied to *Eumolpus* by the mouth not being covered beneath by the prosternum, by the claws being toothed, and by the tibiae being longitudinally sulcate. The head is not sculptured as in *Heteraspis* [*Graphops*]."

The first species, *pubescens*, was described as early as 1777 by Fabricius under *Eumolpus*. Linneaus in 1788 gave this species another name, and he was followed by Olivier in 1808 with still another specific name, and our own early American entomologist, Thomas Say, in 1827 gave a fourth name to this species, which is widespread over the eastern half of the United States. Say also described two other species from the eastern and middle states under *Eumolpus*. In LeConte's paper of 1859 he described *Glyptoscelis albida*, the first species from the West Coast. In 1878, nearly 20 years later, he described *G. longior*, a second western species. In the meantime, in

1873, Crotch, adopting LeConte's generic name *Glyptoscelis*, described from California three more species of this predominately West Coast genus. Thus, very early in American entomological history the genus *Glyptoscelis* was recognized by the leading coleopterists of the day. Both Blaisdell and Van Dyke have added new western species, and most recently N. L. K. Krauss in 1937 in the "University of California Publications in Entomology" has written a short revision of the North American species thereby adding three new subspecies. In the East, Blatchley and Schaeffer have each described a species from the middle and southern states respectively. Schaeffer's species from Texas belongs to the group of *Glyptoscelis* found in Mexico, and Blatchley's species (*G. liebecki*) is undoubtedly the same as one described by Baly (*G. albicans*) in 1865. Baly also described two species from Venezuela and Colombia in 1865. Jacoby in the "Biologia Centrali-Americana" in 1882 described *G. mexicana* from Mexico, and *G. chontalensis* from Nicaragua, and in 1897 he described *G. gigas* from Brazil and *G. paraguayensis* from Paraguay. In 1900 he added *G. dohrni* from Colombia. The French entomologist Lefèvre added *G. gayi* from Chile, a species which was collected by the Chilean entomologist. This represents the total of the species already described except for two or three wrongly ascribed to the genus from the West Indies.

There has been gradually accumulating an extensive collection of specimens of the genus in the California Academy of Sciences, chiefly from the western states but with some from Sonora and Sinaloa in Mexico. Along with this material, I have studied the collections at the U.S. National Museum, the Museum of Comparative Zoology, and the University of Washington. The result of this study of large series has shown that the western states and also western Mexico represent the center of the greatest number of species of the genus, and furthermore it shows that there is a considerable number that have not been recognized or have been confused with already described species. No one up to now apparently has studied the aedeagi, which show clear differences between very similar species. For instance, in the two species *G. aeneipennis* Baly and *G. fascicularis* Baly from Colombia and Venezuela, the differences in the beetles are so slight that Jacoby has united them under one name. But the aedeagi are entirely different, although even I, who know this, cannot tell with a certainty by their outward appearance which is which. In general, *Glyptoscelis* is a very homogeneous genus, many species looking more or less alike and at first glance not readily distinguishable.

All the species of *Glyptoscelis* are comparatively large, measuring from 5 to 14 mm. in length. In color they are deep reddish brown or piceous, sometimes with a coppery or distinctly aeneous green

lustre, sometimes somewhat bronzy, or just shining black. And all of them are pubescent, usually with coarse, white, appressed hairs, sometimes intermixed with yellowish or brown hairs. Rarely is the pubescence in the form of broader scales. There is often a pattern made by the color of the brown and white pubescence, with thicker patches that form spots or vittae, usually on the elytra, but sometimes also on the pronotum. The arrangement of the hairs on the pronotum is significant. In the Mexican and South American species there is usually a bare median line that is impunctate down the pronotum and the hairs spread out from this on each side horizontally. In the more northern species the hairs in the median part of the pronotum are vertically arranged. In *G. squamulata* the pubescence on the pronotum is without any perceptible pattern, being very dense and the hairs broad and scalelike. In only one species are the hairs outstandingly erect over the upper surface, and this is in a peculiar cylindrically shaped species that is probably wingless. It is represented by only one specimen collected at Cotati, Sonoma County, Calif.

These stout robust beetles have a broad head with wide-set eyes and a flat front usually with a median depressed line down from the occiput, a convex prothorax with somewhat rounded or occasionally nearly straight sides, a short broad scutellum, and long, convex elytra. In a few species the tips of the elytra are narrowly prolonged. Always the beetles are more or less coarsely and densely punctate throughout. The legs are short and stout, tibiae without emargination but with a groove, the tarsal joints not very long, and the claw joint, with one exception, toothed. Only in *G. cryptica* is the claw simple. In the location of this claw tooth, there is considerable variation. In some species the claw has a bifid appearance, the tooth being near the apex; in others the tooth is short and near the base, and in some there is only a very tiny median tooth. Most often there is a well-developed tooth about midway up the claw, not as long as the claw.

As already stated, the aedeagus is of prime importance in separating the species. The shape of the tip is not only of specific value but it tends to separate the species into groups. For example, in *G. squamulata*, *G. alternata*, *G. albida*, and *G. cryptica* there are similarly pointed apices to the aedeagus. And the Mexican species from Sinaloa and Sonora, as well as *G. mexicana* from Oaxaca and *G. prosopis* from Brownsville all have similarly shaped tips to the aedeagus. This does not hold, however, in the case of the two South American species already mentioned, *G. acncipennis* and *G. fascicularis*. Now and then there occurs a very divergently shaped aedeagus such as is found in *G. dohrni* from Colombia, in *G. gigas* from Brazil, and in *G. gayi* from

Chile. Each one of these species is rather isolated from other species and otherwise unusual in appearance.

It might be noted here again that, although the genus extends from Canada to Chile, the majority of the species is found in the western states, particularly in California. In the East there are only four species: (1) *G. pubescens*, which ranges from Canada to the Gulf States and from the Mississippi River to the Atlantic Ocean; (2) *G. barbata*, which occurs through the Middle States from Pennsylvania to St. Louis, Mo.; (3) *G. albicans*, which definitely ranges from the Mississippi Valley to Texas; and (4) *G. cryptica*, which is known from west of the Mississippi River in the prairie states. Only a few species have been described from Mexico and Central America, and a few widely separated species from South America. More will probably come to light in the future, but it is unlikely that they will amount to the plurality of the species of our western states.

Not much is known of the biology of any of the species. In the East, *G. pubescens* occurs on various species of pine, *G. barbata* on pine and also hickory. On the West Coast, Blaisdell reported *G. sequoiae* on *Sequoia sempervirens*, and in the Sierras there is one or possibly two species that occur on *Libocedrus decurrens* and *Juniperus occidentalis*. Other species in the Northwest are reported on various species of pine and on fir trees. In Texas the name indicates that *G. prosopis* was found on mesquite. Another species from Argentina has also been collected on *Prosopis*. *Glyptoscelis parvula* is recorded on wild rose and willow, and *G. squamulata* also on willow. *Glyptoscelis illustris* is recorded several times as taken on *Pinus ponderosa* and also on *Juniperus occidentalis*. And two small undescribed species were collected on a pure stand of *Artemisia tridentata* (sagebrush). Thus, in general, it may be concluded that *Glyptoscelis* occurs on woody shrubs or trees, especially coniferous trees. The larvae are underground root feeders.

Krauss in his revision of the species north of Mexico has designated *Glyptoscelis albida* as the type of the genus. It was the first species described by LeConte when he described the genus.

I wish to thank the following persons for lending me specimens for this study: Hugh B. Leech, California Academy of Sciences; Melville H. Hatch, University of Washington; P. J. Darlington, Jr., Museum of Comparative Zoology; and R. D. Pope, British Museum (Natural History).

Key to United States Species of *Glyptoscelis*

1. Claws simple, not toothed, elytra narrowly prolonged at apex, most noticeable in male (Prairie States) ***cryptica*** (Say)
- Claws toothed, elytra not prolonged at apex 2

2. Pubescence erect and fine, not obscuring surface below, elytra without humeral prominences (Sonoma Co., Calif.) . . . **cylindrica**, new species
Pubescence appressed and coarse, more or less obscuring surface below, elytra with well-marked humeral prominences 3
3. Pubescence on pronotum consisting of broad, often truncate scalelike hairs . 4
Pubescence on pronotum not broad or in form of scalelike hairs 5
4. Pubescence on elytra white with lines of brown hairs forming vittae. (Inyo Co., Calif., and nearby) **alternata** Crotch
Pubescence on elytra without lines of brown hairs (California, Nevada, Arizona) **squamulata** Crotch
5. Large (9–11.5 mm.) pubescence on elytra with pattern of dark and white hairs 6
Usually smaller, without noticeable pattern of pubescence on elytra, hairs more evenly distributed 7
6. Pubescence on elytra with pattern of white hairs along base, sides, and suture and short white vittae near apex, rest of elytra with scanty, inconspicuous dark hairs, not hiding coppery surface (California and Oregon).
illustris Crotch
Pubescence on elytra white with coarse yellowish hairs and traces of dark vittae near apex hiding surface (Inyo Co., Calif.) . . . **aridis** Van Dyke
7. Beetle distinctly reddish brown with white pubescence (southern Illinois to Texas) **albicans** Baly
Beetle either reddish brown with brown pubescence or piceous 8
8. Beetle reddish brown with brown pubescence (New York to St. Louis, Mo.).
barbata (Say)
Beetle piceous usually with white pubescence that may be intermingled with brown hairs 9
9. Large (7.5–11 mm.), with prothorax as wide as elytra, piceous, lightly covered with brown and white pubescence (Canada to Gulf of Mexico, Atlantic Ocean to Mississippi River) **pubescens** (Fabricius)
Smaller (from Mississippi River to Pacific Ocean) 10
10. Aedeagus truncate at apex (on *Artemisia tridentata*; Oregon, Washington, Idaho, British Columbia) **artemisiae**, new species
Aedeagus not truncate at apex 11
11. Pubescence on pronotum with more or less distinct median bare line from which hairs spread outwards and downwards (Brownsville, Tex.).
prosopis Schaeffer
Pubescence on pronotum without median bare line 12
12. Beetle with coppery lustre, pubescence never white, varying from yellowish to dark brown (on *Sequoia sempervirens*, from about San Francisco, Calif., to Oregon) **sequoiae** Blaisdell
Beetle either piceous black or bronzy, pubescence usually white or mixed with brown hairs 13
13. Aedeagus triangular at apex (California) **albida** LeConte
Aedeagus not triangular at apex 14
14. Occiput of head nearly smooth with punctures only along median line; elytra with white pubescence forming vittae (on *Artemisia tridentata*; Idaho) **paula**, new species
Occiput of head densely punctate 15
15. Aedeagus broadly rounded at apex 16
Aedeagus not rounded at apex 20

16. Small (5-7 mm.), with short stout antennae not extending much below humeri, thorax contracted at base (on rose or willow; area about Sacramento, Calif.) **parvula** Blaisdell
Usually larger with antennae reaching below humeri, thorax not noticeably contracted at base 17
17. Elytra with hairs forming white vittae (Idaho, Wyoming).
idahoensis, new species
Elytra without white vittae 18
18. Claw with tooth near base (Klamath, Oreg.) **vandykei** Krauss
Claw with tooth at middle or near apex 19
19. Pubescence not coarse, straw-colored or darker, surface shining with aeneous or bronzy lustre (on *Juniperus* or *Libocedrus*; Sierra Mts.).
juniperi, new species
Pubescence coarse and white with a few yellowish hairs; surface piceous with faint bronzy lustre (Colorado, Utah) **coloradoensis**, new species
20. Elytral pubescence mostly dark brown with a few white hairs, giving beetle brown look (Humboldt Co., Calif., to British Columbia, east to Montana).
septentrionalis, new species
Elytral pubescence not dark brown, appearing grayish 21
21. From 7-8 mm. long (Cascade Range in Shasta, Siskiyou, Trinity Cos., Calif.) **peperi**, new species
From 5.5-6.5 mm. long (from middle of Oregon eastward to Idaho, Wyoming) **longior** LeConte

Glyptoscelis pubescens (Fabricius)

FIGURE 1

Cryptocephalus pubescens Fabricius, 1776, Genera insectorum, p. 220; 1801, Systema eleutheron, vol. 2, p. 43.

Eumolpus hirsutus Gmelin, 1788, edition of Linnaeus, Systema natura, vol. 1, p. 1703.

Eumolpus hirtus Olivier, 1808, Entomologie, vol. 6, p. 906.

Eumolpus pini Say, 1827, Journ. Acad. Nat. Sci. Philadelphia, vol. 5, p. 295.

Glyptoscelis hirtus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, vol. 25, p. 35.

Glyptoscelis pubescens Horn, 1892, Trans. American Ent. Soc., vol. 19, pp. 202,

203.—Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, pp. 23, 24.

From 7.5 to 11 mm. in length, oblong oval, shining piceous with a bronzy or sometimes faint rosy lustre; legs and antennae deep reddish brown, prothorax with dense, deep, and coarse punctation, elytra a little less coarsely and less densely punctate, especially toward the apex; surface not entirely concealed by brown and white pubescence that is semierect; prothorax nearly as broad as elytra, not very convex, and with well-rounded sides.

Head with interocular space considerably more than half width of head, eyes emarginate near antennal sockets; a median depression from which a median line up to occiput, punctation over front and occiput dense, deep and variable in coarseness; a whitish pubescence about eyes, brownish in middle of front, labrum reddish brown. Antennae extending well below humeri, seventh joint long, outer joints wider and often deeper brown. Prothorax not as convex as in

most species of the genus, at middle nearly as wide as elytra, sides well rounded, surface shiny, very densely, deeply and coarsely punctate, punctures tending to be oval, not entirely concealed by the brown and white pubescence that in places is semierect. Scutellum black with a few fine white hairs. Elytra with prominent humeri and short intrahumeral sulcus, a slight depression below basal callosities and another below scutellum; punctation usually coarse, deep and dense in basal half, becoming much finer towards apex; pubescence of mixed brown and white semierect coarse hairs, not scales and not hiding punctation. Body beneath with thick white pubescence not entirely obscuring the shiny punctate surface beneath. Legs reddish brown. Length 7.4–11 mm.; width 3.7–5.3 mm.

Type: One specimen in the Fabricius collection at Kiel, Germany. Type-locality: "Habitat in America boreali."

Other localities: ONTARIO: Toronto, R. J. Crew, M. C. Van Duzee. QUEBEC: St. Johns, June 1, 1902; F. Knab. NEW HAMPSHIRE: Exeter, Durham, A. S. Abbott. MINNESOTA: Itasca. MASSACHUSETTS: Brookline, Boston; Mt. Toby, Sunderland, May 12, 1918, H. M. Parshley; Chicopee, May 1900, F. Knab; Concord, Forest Hills, F. X. Williams; Framingham, G. M. Greene; Springfield, May 12, 1900; Stoneham, F. A. Sheriff; Stoughton, June 1919, D. H. Blake; N. Saugus, D. H. Clemens; Worcester, F. Knab. NEW YORK: West Point, June 26, 1912, Wirt Robinson; Ithaca, F. H. Chittenden; Buffalo; Trenton, Hubbard and Schwarz; on pine, Wyoming Co., June 1900, G. M. Greene; Bear Mt., July 2, 1924; Hamburg, May 3, 1913, Van Duzee. NEW JERSEY: Da Costa, June 30; Atsion, June 26, 1950, G. M. Greene; Glenwood Lake, Hornerstown, Lakehurst, Van Dyke; Iona, May 26, 1902; Malaga, Apr. 26, 1925, R. R. Mason. PENNSYLVANIA: Wind Gap, June 25, 1930, G. M. Greene; Bedford Co.; Mt. Pocono, Pocono Lake, G. M. Greene; Water Gap; Dauphin Co., May 21, 1927, J. N. Kault; Effort, July 22, 1932, G. M. Greene; Tannersville, June 21, 1948, G. M. Greene. MARYLAND: Bladensburg, Apr. 6, 1919, L. L. Buchanan; Chesapeake Beach, May 6, 1906, F. Knab. WASHINGTON, D.C.: Petworth, W. Middleton; Hubbard and Schwarz on *Pinus virginica*. VIRGINIA: Charlottesville, R. C. Smith; Falls Church, J. M. Green, June 3, 1917; Newport News, H. B. Barley, Norfolk, May 21, 1931, H. G. Walker; Fredericksburg; Ft. Monroe, Apr. 19, Hubbard and Schwarz; Vienna, Apr. 15, 1942, on *Pinus taeda*; Luray, Hubbard and Schwarz; St. Elmo, April. NORTH CAROLINA: Asheville, on *Pinus rigida*, May 11, 1924; Retreat, May 31, Hubbard and Schwarz; Round Knob, Hubbard and Schwarz; Southern Pines, Apr. 26. SOUTH CAROLINA: Clemson, June 27, 1946, O. L. Cartwright. MISSISSIPPI: Mar. 16, Nicholson. ALABAMA:

Auburn, Apr. 18, 1940, Van Dyke; one-half mile east of Paeston, Marshall County, on *Pinus taeda*.

Remarks: This is the most common and widespread species of *Glyptoscelis* east of the Mississippi River, and its range is from Ontario and Quebec to Mississippi and Alabama, and from Minnesota eastward. It is recorded as being found on various species of pine, also on hemlock and spruce. This large stout beetle with its brownish coloration and its exceptionally wide prothorax is easily distinguished from other species. There is considerable variation in size, specimens from the more southern localities tending to be the largest.

Glyptoscelis barbata (Say)

FIGURE 2

Eumolpus barbatus Say, 1826, Journ. Acad. Nat. Sci. Philadelphia, vol. 5, p. 296.
Glyptoscelis barbatus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, vol. 25, p. 36.

Glyptoscelis barbata Horn, 1892, Trans. American Ent. Soc., vol. 19, pp. 202, 203.—
Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 24.

Between 6 and 7.5 mm. in length, oblong oval, shining beneath semierect brown pubescence, deep reddish brown or even piceous, antennae reddish brown, very coarsely and densely punctate with transverse ridging on elytra, pubescence beneath grayish white.

Head with interocular space more than half width of head, a median line down occiput and front, deep reddish brown, surface deeply, densely and not very coarsely punctate, covered with brown pubescence. Antennae extending below humeri, reddish brown, outer joints a little wider, seventh joint long. Prothorax moderately convex with rounded sides, deep reddish brown, punctation deep, contiguous and tending to be oval, not entirely concealed by semierect brown pubescence. Scutellum with a few hairs. Elytra broadly rounded posteriorly, with a short intrahumeral sulcus, not noticeably depressed below scutellum, a little elevated at middle, shining beneath the reddish brown and semierect pubescence, punctures coarse, deep and with transverse ridging. Body beneath shining beneath the dense grayish pubescence, legs reddish brown with gray pubescence. Length 6–7.5 mm.; width 3.3–4 mm.

Type: Whereabouts unknown.

Type-locality: Not given by Say, who stated that it was a beetle named in the Melsheimer Catalogue, and it is probably from the Melsheimer collection and from Pennsylvania.

Other localities: NEW YORK: New York, Long Island, and Staten Island, all collected by M. L. Linell. NEW JERSEY: M. L. Linell. PENNSYLVANIA: Alleghany, J. B. Smith, Red Bank, July 2, 1900; Shiremanstown, May 15, 1915, on *Carya* foliage, W. S. Fisher; Lingles-

town, October 1914, W. S. Fisher, on *Carya*; Philadelphia, Caby, J. W. Green; Hammelstown, June 4, 1921, J. N. Knull; Overbrook, June 31, 1915, G. M. Greene; Angora, G. M. Greene. MARYLAND: Beltsville, June 30, 1923, L. L. Buchanan. WASHINGTON, D.C.: Hubbard and Schwarz. VIRGINIA: Herndon, Hubbard and Schwarz. KENTUCKY: Edmonson Co., July 17, 1900. MISSOURI: St. Louis, June 1899, F. Knab. INDIANA: Clark Co.

Remarks: The distinctly brown appearance of this species is the result not only of its reddish-brown surface but also the uniformly pale brown pubescence on the upper surface. The body beneath has a grayish pubescence. No specimens have been seen north of New York or south of Kentucky. It is recorded from New York to as far west as St. Louis, Mo.

Glyptoscelis albicans Baly

FIGURE 5

Glyptoscelis albicans Baly, 1865, Trans. Ent. Soc. London, ser. 3, vols. 2, 4, p. 334.

Glyptoscelis liebecki Blatchley, 1910, Coleoptera of Indiana, p. 1137.—Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 24.

Between 8 and 10 mm. in length, oblong oval, shining, deep reddish brown with short, white, coarse, appressed pubescence, prothorax deeply, coarsely, and densely punctate, elytra not quite so coarsely or densely punctate with some horizontal ridging, slightly depressed below scutellum and convex below that.

Head with interocular space more than half width of head, a more or less distinct median line ending in a depression in middle of front, punctation dense and moderately coarse, brown and white pubescence very dense, covering surface, usually labrum and palpi paler yellowish brown. Antennae extending well below humeri with wider outer joints, seventh joint long, pale yellowish or reddish brown. Prothorax not much wider than long, with only slightly curved sides, moderately convex, densely and deeply punctate, punctures being somewhat oval and frequently contiguous, covered densely with a pale brown or yellowish gray coarse pubescence, heavier on the sides. Scutellum with a few fine hairs. Elytra with a depression below scutellum along suture, a short intrahumeral sulcus and well-developed humeri, a slight convexity before middle of elytra; punctation not so coarse or deep as on pronotum with horizontal ridging most marked about scutellum, punctures finer toward apex; pubescence coarse, short, dense, closely appressed, tending to be yellowish or pale brownish or white, and surface below dark reddish brown and shiny. Body beneath covered with dense white coarse hairs, beneath which a dense fine

punctuation, legs yellowish or reddish brown. Length 8–10.5 mm.; width 4–5 mm.

Type: Female, in British Museum (Natural History). Type of *G. liebecki* in Blatchley collection, Purdue University, Lafayette, Ind.

Type-locality: For its habitat Baly gives only “?”.

Other localities: ILLINOIS: southern part, May 7, 1892, H. Soltan. ARKANSAS: Pine Bluff, Mar. 20, Hubbard and Schwarz. LOUISIANA: Tallulah, Mar. 8–15, 1944. TEXAS: College Station, Apr. 1, 1917; Texas, C. V. Riley.

Remarks: The reddish-brown color and coarse white hairs distinguish this from other eastern species. It closely resembles *G. cryptica* Say in its coloring but the scalelike pubescence in *G. cryptica* is broader and there are more distinct elytral prolongations at the tip than in *G. albicans*. Sometimes in *G. albicans* there may be a bunching of the white hairs at the tip to simulate a little prolongation.

Glyptoscelis albicans Baly has been synonymized with *G. cryptica* Say. I have examined the Baly type in the British Museum (Natural History), and it has no prolongation of the tip as in *G. cryptica*. The elytra are covered with a dense white pubescence that conceals the punctuation, the hairs are not so short or broad as in *G. cryptica*. The elytra are not at all metallic and are slightly humped in the middle, well below the scutellum. Jacoby's observation (under *G. albicans* in the “Biologia Centrali-Americana,” Coleoptera, vol. 6, pt. 1, 1882, p. 177) that his specimen from the Sallé collection with simple claws differs in this respect from the type of *G. albicans*, which has bifid claws, is sufficient to rule out *G. albicans* from being the same as *G. cryptica* Say.

The pattern of the pubescence on the prothorax is different from that of the *G. squamulata* group and also of species from Mexico. In fact, the only species that can fit *G. albicans* is Blatchley's *G. liebecki*, which strongly resembles *G. cryptica*, except that it has bifid claws.

Blatchley gave the distribution in Indiana as Knox, Martin, and Posey Counties, all in the southwest part of the state. It is also from southern Illinois but there are no records from farther north or east. It ranges south and west to Texas.

Glyptoscelis cryptica (Say)

FIGURE 3

Eumolpus crypticus Say, 1824, Journ. Acad. Nat. Sci. Philadelphia, vol. 3, p. 449.

Glyptoscelis crypticus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, vol. 25, p. 36.

Glyptoscelis cryptica Horn, 1892, Trans. American Ent. Soc., vol. 19, pp. 202, 204.—Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 30.

From 8 to 10.5 mm. in length, oblong oval, shining reddish brown beneath the short white scalelike pubescence, elytra with prolonged tips parted, more developed in male, claws simple.

Head with interocular space more than half width of head, eyes slightly emarginate at antennal sockets; a more or less well-defined median line ending in a small depression in middle of front, from which white pubescence radiates, surface lustrous, dark reddish brown, densely punctate, covered with dense, coarse white hairs, labrum paler reddish brown. Antennae extending below humeri, outer joints thicker, seventh joint long, reddish brown. Prothorax widest at base, with nearly straight sides, moderately convex, in some specimens a median depression, more marked in middle of base; surface shiny, densely and not very coarsely punctate, lustrous dark reddish brown, covered with short, dense, coarse, white hairs, sometimes almost scalelike. Scutellum with fine white hairs. Elytra a little depressed below scutellum and with a short intrahumeral sulcus and prominent humeri, tapering to apex with apices prolonged and parted, especially in male, not united at tip as in *G. chontalensis* Jacoby; surface very shiny, dark reddish brown, with punctation coarser near base, covered with scalelike white pubescence, wider than hairs on prothorax. Body beneath densely punctate and with white scalelike pubescence becoming finer on abdomen, claws simple. Length 8–10.5 mm.; width 4–5 mm.

Type: Whereabouts unknown.

Type-locality: "Inhabits Missouri."

Other localities: MISSOURI: St. Louis; central Missouri, C. V. Riley. ARKANSAS: Pine Bluff, Mar. 22, Hubbard and Schwarz. INDIANA. OKLAHOMA: Oklahoma City, May 28, 1957, O. Alexander. KANSAS: East Kansas; Topeka, E. A. Popenoe.

Remarks: I have seen very few specimens of this species, and these are mostly old ones from the Riley and Popenoe collections. The reddish-brown coloring, scalelike pubescence on the elytra, and prolonged and parted apices of the elytra, more developed in male, distinguish this species. It is unique in the genus in having simple claws.

There is a figure of this species in the "Biologia Centrali-Americana" (Coleoptera, vol. 6, p. 177, 1882) illustrating a specimen, probably a female, from the Sturm collection and labelled "Mexico," which Jacoby called *G. albicans* Baly, although he noted that it differed from *G. albicans* by having simple not bifid or appendiculate claws.

Glyptoscelis squamulata Crotch

FIGURE 6

Glyptoscelis squamulatus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, p. 35.
Glyptoscelis squamulata Horn, 1892, Trans. American Ent. Soc., vol. 19, p. 204.
Glyptoscelis squamulata Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 29.

From 6.5 to 10 mm. in length, elongate oblong oval, bronzy black beneath the dense, closely appressed white or pale brownish scales, densely and not very coarsely punctate, antennae and legs reddish brown.

Head with a more or less distinct median line ending in a depression in middle of front from which white scalelike hairs radiate; densely pubescent over the dense punctation beneath; eyes with small emargination near antennal sockets, labrum reddish brown. Antennae extending a little below humeri, outer joints somewhat wider, seventh joint long, reddish brown with some darkening of apical joints. Prothorax wider than long with curved sides, moderately convex, often depressed in middle at base; densely covered with white or pale brownish scales set vertically except toward margin, where scales become horizontally arranged; punctation dense, deep, and not very coarse, tending to be oval rather than round and on sides punctures sometimes running together. Scutellum with fine hairs. Elytra faintly depressed about scutellum and with a transverse depression below intrahumeral sulcus, piceous surface completely hidden by dense scales, punctation beneath the dense covering coarser in basal part becoming finer and less dense towards apex. Body beneath entirely covered with dense white pubescence, the scales over abdomen more hairlike; legs reddish brown. Length 6.5–10 mm.; width 3.3–5 mm.

Type: In Museum of Comparative Zoology.

Type-locality: California.

Other localities: CALIFORNIA: Butte Co.: Oroville, Apr. 30, 1927, H. R. Keefer. Lake Co.: Hillville, June 19, 1921, F. E. Blaisdell. Sacramento Co.: Sacramento, on willow, May 28, 1918, E. P. Van Duzee; Courtland, May 6, 1926, F. H. Wymore. Merced Co.: Ryer, May 3, 1923, F. H. Wymore. San Joaquin Co.: Davis, Apr. 17, 1926, Wymore, on *Salix*. Stanislaus Co.: La Grange, R. P. Allen. Alameda Co.: Sunol, May 14, 1922, F. E. Blaisdell. Madera Co.: Madera, Apr. 11, 1951, R. Pallen. Santa Clara Co.: San Jose, Apr. 16, 1940, E. G. Meyers. Fresno Co.: Bass Lake, June 12, 1922, R. S. Wagner; Sanger, on grapes, Apr. 8, 1936; Coalinga, Mar. 19, 1931, E. S. Ross. Monterey Co.: Bradley, May 23, 1930, on willow, E. P. Van Duzee; Bryson Paicenes, July 9, 1933; Paraiso Spgs., Apr. 26, 1919. San Luis Obispo Co.: Paso Robles, Apr. 1, 1917, on *Salix*, L. S. Slevin. San Benito Co.: Hernandez Valley, May 28, 1960, C. E. Wemmen. Tulare Co.: Woodlake, Visalia, Mar. 7, 1934, R. P. Allen. Kings Co.: Hanford, eating grape leaves, Van Dyke. Kern Co.: Bakersfield, June 2, 1916, J. O. Martin; Cuyama Valley, Apr. 10, 1932, E. P. Van Duzee; Poso Creek, June 5, 1929, E. P. Van Duzee; Tapman, Apr. 7, 1922, E. P. Van Duzee;

Isabella, June 2, 1943, R. Hopping; Del Ray, Hubbard and Schwarz. Los Angeles Co.: Palmdale, Santa Monica, Rivera, on orange, May 10, 1926, Van Duzee; San Gabriel, June 1892, Hutchinson; Pasadena, May, Fenyès; Compton, Apr. 17, 1912, J. E. Graf; West Covina, May 4, 1942, J. A. Wilcox, on young orange trees; Lenwood, Burbank, July 1915; Whittier, Mar. 20, 1940, Harper and Graves. Riverside Co.: Coachella, Mar. 15, 1920; Indio, on grape leaves, Mar. 17, 1938, G. Henuil; Palm Springs, A. Fenyès, May 21, 1917, E. P. Van Duzee; Saboba Springs, June 2, 1917, E. P. Van Duzee. San Bernardino Co.: Colton, May 26, 1917, E. P. Van Duzee, on rose; Courtland, May 6, 1926, F. H. Wymore; San Bernardino, May 13, 1930, C. M. Dammus; Lytle Creek, June 6, 1926, Van Duzee; Oro Grande, E. S. Ross. Orange Co.: Green River Camp, Santa Ana, May 11, 1933, E. P. Van Duzee. San Diego Co.: Descanso, Mission Valley, April 1930, G. H. Field; San Diego, May 31, 1890, F. E. Blaisdell, on alfalfa, Apr. 10, 1914, S. Wilson. Imperial Co.: Winterhaven, on *Sphaeralcea rosacea*, March 1930. NEVADA: Reno, May 3, 1926; Las Vegas Valley, Lincoln Co., May 1922, injuring grape leaves; Logandale, Apr. 14, 1961, Bechtel. UTAH: Milford, July 7, Wickham; St. George, V. M. Tanner; St. George, 2800 ft., May 23–June 12, 1919, W. Knaus. ARIZONA: Ft. Yuma, Jan. 25, Hubbard and Schwarz; Littlefield, Apr. 25, 1935, J. W. Green; Phoenix, Tempe, V. L. Wildermuth; Somerton, Mar. 23, 1944, on alfalfa.

Remarks: There are five specimens in the LeConte collection under *G. squamulata*, the first two bearing round gilt labels, indicating the locality as California. These are essentially alike in white appearance and are probably Crotch's specimens. The species is readily distinguished from all the others by the wide white or pale brownish scales covering the whole beetle and giving it a snowy appearance. There are rarely brown specimens. It appears to range from Butte County in northern California to San Diego County in the south, and it also occurs in Utah, Nevada, and Arizona. It has been recorded as a pest on grapes, oranges, and peaches.

***Glyptoscelis alternata* Crotch**

FIGURE 4

Glyptoscelis alternatus Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, vol. 25, p. 36.

Glyptoscelis alternata Horn, 1892, Trans. American Ent. Soc., vol. 19, pp. 202–3.

Glyptoscelis alternata Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, pp. 29, 30.

Between 7 and 9.5 mm. in length, elongate oblong oval, shining piceous, covered with closely appressed brown and white scales, scales on elytra forming brown and white vittae; punctation on pronotum

oval, denser on sides and at base, elytra with depressed area near scutellum and below basal callosities, punctures not very coarse and becoming finer towards apex.

Head coarsely and densely punctate throughout with closely appressed white scalelike hairs that, on occiput, become slightly browner; surface piceous, labrum usually brown. Antennae extending below humeri, brown with fine white pubescence. Prothorax moderately convex, depressed along base, shining piceous with coarse elongate oval punctures becoming denser at base and on sides and nearly concealed by the closely appressed white pubescence. Scutellum densely punctate and densely covered with finer white hairs. Elytra with a depressed white area below and about scutellum in which horizontal rows of punctures form slight horizontal ridging between, a transverse depression below with ridging, and a short intrahumeral sulcus, punctation becoming finer and less dense towards apex, pubescence consisting of scalelike hairs with alternate brown and white coloring forming a vittate pattern. Body beneath entirely covered with closely appressed white pubescence, near apex of tibiae becoming fine, silky, and slightly brownish. Length 7–9.5 mm.; width 3.3–5.3 mm.

Type: Possibly in Horn collection in Philadelphia.

Type-locality: California.

Other localities: CALIFORNIA: Inyo Co.: Independence, June 11, 1937, Van Dyke, June 12, K. L. Maehler, June 4, Fenyès; Big Pine, Apr. 10, 1937, A. E. Michelbacher; Lone Pine, Apr. 6, 1934, R. P. Allen; June 8, 1929, R. L. Usinger; Oct. 10, 1937, H. E. Michelbacher. Krauss gives the locality Isabella, Kern County, which is not far from the localities in Inyo County.

Remarks: As Krauss noted, this species is very close to *G. squamulata* Crotch, the only differences seeming to be in the vittate pattern of the scales on the elytra. The difference in the width of the scales is very slight, *G. squamulata* having possibly slightly shorter and broader scales. The tooth on the claw is lower down than on *G. squamulata*. Unlike *G. squamulata*, this beetle appears to be confined to a small area in southern California in and near Inyo County.

In the LeConte collection there are five specimens under this name, none with a type label, and only one with a locality label, which reads "Tex." In the general collection at the Museum of Comparative Zoology there is one specimen labelled "*alternatus* Cr. Calif. Horn," which is the same data that Crotch gave in his original description of *G. alternata*. Possibly this is the type or at least a cotype.

Mr. Hugh B. Leech has sent me this note from Dr. Van Dyke's notebook: "Friday, June 11, 1937. Drove up to Independence (Inyo Co., Cal.) and thence up Clark Flatroad to Sierras. Collected

but little at higher levels. On way back drove out beyond Independence and towards the river. Close to flume found *Glyptoscelis alternata* on vetch [*Glycyrrhiza lepidota* (Nuttall)]." There are in the California Academy about 70 specimens that Dr. Van Dyke collected that day at Independence.

Glyptoscelis albida LeConte

FIGURES 7, 8, 10

Glyptoscelis albidus LeConte, 1859, Proc. Acad. Nat. Sci. Philadelphia, vol. 9, p. 81.—Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, vol. 25, p. 36.

Glyptoscelis albida Horn, 1892, Trans. American Ent. Soc., vol. 19, p. 203.

Glyptoscelis albida Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, pp. 25-26.

From 6 to 10.5 mm. in length, oblong oval, shining piceous with a bronzy and often purplish-brown lustre beneath the thick white and sometimes pale brownish coarse hairs; antennae, tibiae, and tarsi tending to be dark reddish brown; prothorax contiguously and coarsely punctate, with pubescence vertical in middle and branching from either side of middle of base diagonally toward side; elytra broad, convex, depressed a little about scutellum.

Head with interocular space more than half width of head, a median line down front ending in a depression in middle from which white pubescence radiates, densely and coarsely punctate and covered with dense white appressed hairs; eyes slightly emarginate at antennal sockets. Antennae extending below humeri, dark brown, outer joints wider, seventh joint long. Prothorax large, broader than long with rounded sides, convex with median basal depression; very coarsely and contiguously punctate and covered with white coarse hairs arranged vertically down middle and branching from either side of base diagonally and horizontally toward sides in broad sweeping pattern. Scutellum with finer white hairs. Elytra broad, convex, a slight depression below scutellum and a short intrahumeral sulcus; punctation coarse, often contiguous near base and somewhat horizontally ridged; pubescence dense and coarse, but not entirely hiding surface and producing a grayish white aspect to beetle, the white hairs intermixed with pale brown ones. Body beneath densely punctate and densely covered with finer white hairs becoming silky and yellowish brown at apex of tibiae. Length 6.2-10.5 mm.; width 3.3-5.3 mm.

Type: In Museum of Comparative Zoology. Types of *G. albida diabola* and *G. albida yosemitae* Krauss in California Academy of Sciences.

Type-locality: Ft. Tejon, Calif.

Other localities: CALIFORNIA: Alameda Co.: Niles Canyon, May 14, 1922, Van Dyke; Altomont, Apr. 30, 1956, R. P. Allen; hills back of Oakland. Contra Costa Co.: Berkeley, Apr. 19, 1940, Miller;

Mt. Diablo, May 13, 1923, F. E. Blaisdell. Monterey Co.: Monterey, Koebele; Paraiso Springs, May 31, 1916, Slevin; Bryson, Apr. 25, 1941, E. P. Van Duzee. Mariposa Co.: Wawona, Apr. 17, 1931, feeding on cherry; Yosemite Valley, May 28, 1921. Fresno Co.: Huntington Lake, May 8, 1931, Van Dyke; Havilah, May 8, 1931, Van Dyke; Stevenson Creek, May 27, 1915, on *Libocedrus*; Black Mt., July 5, 1919, F. E. Blaisdell. Tulare Co.: Atwood's Mill, June 29, 1913, Van Dyke; Visalia, April 1930, on poplar, F. T. Scott. San Benito Co.: Waltham Creek, May 11, 1907, R. Hopping. Kern Co.: Mt. Pinos, June 14, 1914, F. Grinnell. Ventura Co.: Mt. Pinos, June 15, 1914, F. Grinnell. San Bernardino Co.: Forest Home, June 14, 1928, Van Dyke; Lebec, alt. 4000 ft., May 15, 1928, J. O. Martin. Los Angeles Co.: Tanbark Flat, June 23, 1950, F. X. Williams. Riverside Co.: Palm Springs, Mar. 27, 1916, F. E. Blaisdell. San Diego Co.: Mission Valley, Mar. 30, 1930, Ian Moore. Imperial Co.: Laguna, June 3, 1924, F. E. Blaisdell.

Remarks: In the LeConte collection are four specimens, the first labelled "*G. albidus* Lec. Sac. Rathv." and having, in addition, a round gilt label indicating "California." The other three all have gilt labels and two are also labelled "Santa Cruz." There are two others in the same line labelled "Cal." that are probably not this species. The type bearing the label is almost destitute of pubescence, being badly rubbed. A drawing was made of this one, which presumably was taken at Ft. Tejon, and with it is given the aedeagus of a specimen from Lebec, which is located in Kern County near the type-locality, Ft. Tejon.

The grayish-white appearance of this species is responsible for its name. It is not snowy white like *G. squamulata* Crotch, and the coarse white hairs are pointed and not truncate as are the scales in *G. squamulata*.

Krauss has made two subspecies, one, *G. diabola* from Mt. Diablo, Contra Costa County, which he differentiates by its less robust form, more aeneous coloring and less densely punctate thorax. The other, *G. yosemitae*, he differentiates by its less robust form, somewhat less densely pubescent surface, with shorter and finer hairs, and more shallowly emarginate eyes. There is a great variation in size in this species, which, I believe, is not connected with specific localities. The main character is to be found in the aedeagus. This is not unlike that of *G. squamulata* and serves to distinguish *G. albida* from the three following species, all more northern in range, that occur respectively in northern California, Oregon, and Idaho.

Glyptoscelis vandykei Krauss, new status

FIGURE 9

Glyptoscelis sequoiae vandykei Krauss, 1937, Univ. Calif. Publ. Ent., vol. 7, no. 2, p. 28.

From 8 to 10 mm. in length, broadly oblong oval, shining piceous, antennae usually very dark brown or piceous, prothorax broad, densely and deeply punctate, elytra coarsely and contiguously punctate, covered with coarse white and pale brown hairs, not closely appressed.

Head with interocular space more than half width of head, eyes slightly emarginate at antennal sockets, a more or less well-defined median line ending in a depression in middle of front, lower front more coarsely punctate, punctures dense on head with rather fine and closely appressed white and pale brown pubescence. Antennae long, extending well below humeri, outer joints wider, seventh joint long, usually dark brown or piceous. Prothorax considerably wider than long, almost as wide as elytra, with curved sides, moderately convex with depression along basal margin; deeply, coarsely and densely punctate, punctures oval or even sometimes diamond shaped; pubescence long and moderately coarse, in middle usually pale brown and semierect, not entirely concealing punctation, below middle the pattern of pubescence branching horizontally toward sides and feathery. Scutellum with finer white pubescence. Elytra slightly depressed below scutellum and also below basal callosities, a short intrahumeral sulcus; punctation contiguous, coarse, with horizontal ridging about scutellum; pubescence not so thick as to conceal punctation below, coarse, not closely appressed but semierect, pale brown and white. Body beneath densely punctate and covered with white pubescence. Length 7.6–9.7 mm.; width 4–5 mm.

Type: In California Academy of Sciences.

Type-locality: Klamath Falls, Klamath County, Oreg., June 16, 1922, Van Dyke, on juniper.

Other localities: OREGON: Crater Lake, alt. 7000 ft., July 17, 1922, Van Dyke.

Remarks: This species is easily separated from *G. sequoiae* Blaisdell by its larger size, coarser pubescence, and different coloring. *Glyptoscelis sequoiae* is noticeable because of its coppery lustre, whereas *G. vandykei* is piceous. The aedeagus is also quite different in shape, in *G. vandykei* being broadly rounded at the apex. The pubescence is not so coarse as in *G. albida*, which otherwise it resembles in size and robustness, and again the aedeagus is quite unlike that of *G. albida*. Unlike *G. sequoiae*, its food plant is apparently juniper.

Glyptoscelis peperi, new species

FIGURE 12

From 7 to 8 mm. in length, oblong oval, shining black, antennae, tibiae, and tarsi tending to be deep reddish brown, covered with white and pale brownish hairs intermingled, those on the elytra being coarser than on pronotum, punctation of pronotum dense, deep, and moderately coarse, of elytra coarser near base, a depression below scutellum and on side below basal callosities.

Head with interocular space more than half width of head, eyes emarginate at antennal sockets, a median line more or less distinct down front ending in a depression and the lower front slightly produced between antennal sockets; punctation dense and becoming coarser in lower front; covered with white and pale brownish appressed hairs, finer over occiput. Prothorax slightly wider than long, convex, with curved sides and depression along base, shining, deeply and moderately coarsely and densely punctate, the punctures being oval frequently, and covered with white and pale brownish appressed hairs, not as coarse as on elytra and below middle branching horizontally toward side in feathery pattern. Scutellum with fine dense white hairs. Elytra depressed about scutellum and with a short intrahumeral sulcus and a depression on side below basal callosities; punctation dense, not very coarse with some horizontal ridging below scutellum; pubescence coarse, white hairs usually intermingled with pale brownish ones. Body beneath densely punctate and covered with white hairs not so coarse as on elytra. Length 7–8.2 mm.; width 3.5–4 mm.

Type: Male, California Academy of Sciences, and 38 paratypes, of which 10 are in the U.S. National Museum.

Type-locality: Shasta Springs, Calif., June 1920, C. L. Fox.

Other localities: CALIFORNIA: Shasta Co.: Castle Crag, Fenyes; Old Station, June 1941, H. P. Chandler; Cayton, July, E. P. Van Duzee; Burney, June 1941, H. P. Chandler. Siskiyou Co.: Walker, July 1920, C. L. Fox; McCloud, June 1914, Van Dyke; Siskiyou, May 1911, Nunenmacher. Trinity Co.: Carrville, 2400–2500 ft., June, Van Dyke.

Remarks: This is one of several species liable to be confused with *G. albida* because of its coarse pubescence. It is slightly smaller and less robust than *G. albida*, and the pubescence, while coarse, is not as long and is usually composed of brown and white hairs intermingled. The aedeagus is quite unlike that of *G. albida*, being more rounded at the apex. Krauss has confused this species with *G. sequoiae* described from Sonoma Co., but *G. sequoiae* beside being generally slightly smaller has finer and browner pubescence, and the surface a coppery lustre. *Glyptoscelis peperi* is also a bit larger than the

Sierra species, *G. juniperi*, and the pubescence coarser and the tip of the aedeagus not so broadly rounded.

***Glyptoscelis idahoensis*, new species**

FIGURE 11

From 7 to 8 mm. in length, oblong oval, shining piceous beneath coarse white pubescence; prothorax densely and coarsely punctate, elytra coarsely and rugosely punctate toward base, finer toward apex; pubescence on elytra sometimes with vittate lines.

Head with interocular space more than half width of head, a depressed median line down front ending in a depression from which coarse white hairs radiate, whole head densely covered with white hairs, beneath which are dense, coarse punctures; eyes slightly emarginate at antennal sockets. Prothorax slightly wider than long with rounded sides, densely, deeply, and quite coarsely punctate, punctures elongate or diamond shaped and covered not densely with coarse white hairs in a pattern that branches a little below the middle with feathery formations toward the sides. Scutellum with a few white hairs. Elytra with very little depression below scutellum, a short intrahumeral sulcus; punctation coarse with horizontal ridgings in basal part, punctation becoming finer toward apex, and not entirely concealed by coarse white hairs that tend to form two vittate lines on each elytron. Body beneath densely punctate and pubescent, tibiae, tarsi and antennae tending to be dark reddish brown. Length 7–8.2 mm.; width 3.7–4.2 mm.

Type: U.S. National Museum no. 69196 and 3 paratypes.

Type-locality: Pocatello, Idaho, Hubbard and Schwarz, 2 specimens from same locality in Wickham collection.

Other localities: WYOMING: Fremont Co., Apr. 29, 1949. Niobrara Co., July 1, 1943, R. E. Pfadt.

Remarks: This species is very like *G. albida* LeConte in size and shape, and also in its coarse white pubescence, and Schwarz has labelled it as that species. But the hairs, while coarse, are not so long as in *G. albida*, and the pattern of the pubescence on the prothorax as well as the tendency to form vittae on the elytra is different. The aedeagus too is entirely unlike that of *G. albida*, being rounded and not triangular at the apex.

***Glyptoscelis sequoiae* Blaisdell**

FIGURE 13

Glyptoscelis sequoiae Blaisdell, 1921, Stanford Univ. Publ. Biol. Sci., vol. 1, no. 3, pp. 195–6.—Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 27.

Between 6.5 and 8 mm. in length, elongate oblong oval, shining usually with a coppery, sometimes bronzy lustre; antennae and legs

deep reddish or dark brown; punctation dense, deep but not very coarse; pubescence fine and brownish, not concealing surface below.

Head with interocular space over half width of head, densely punctate, punctures on lower front coarser, median line ending in a depression in middle of front; finer dark hairs on occiput becoming coarser on front and sometimes paler but not white. Antennae extending well below humeri, slender, seventh joint long, outer joints a bit wider, reddish brown to dark brown. Prothorax somewhat wider than long with somewhat curved sides, convex, densely, deeply but not very coarsely punctate with fine brown pubescence, not concealing surface in middle, where the hairs become finer and darker and inconspicuous. Scutellum with a few fine short hairs. Elytra with prominent humeri, an intrahumeral sulcus and a transverse depression below basal callosity, depressed below scutellum, punctation not very coarse or dense but with horizontal ridgings. Body beneath finely punctate and covered with fine yellowish pubescence, legs tending to be deep reddish brown, often darker. Length 6-8 mm.; width 3-4.4 mm.

Type: Male, in California Academy of Sciences.

Type-locality: Cazadero, Sonoma County, Calif., Apr. 12, 1918, E. P. Van Duzee, on foliage of *Sequoia sempervirens*.

Other localities: CALIFORNIA: Sonoma Co.: Guerneville, May 30, 1908, Van Dyke; Sonoma Co., E. S. Ross. Mendocino Co.: Pygmy Forest, May 7, 1936, Van Dyke; Comptech, May 7, 1936, Van Dyke. Humboldt Co.: Green Point, June 4, 5, 1916, F. E. Blaisdell; Weott, June 4, 1936, Van Dyke; Humboldt Co., May 20, 1911, F. W. Nunenmacher. Santa Cruz Co.: Santa Cruz Mts., Koebele. San Mateo Co.: Portola St. Park, May 7, 1950, R. E. Leech.

Remarks: Primarily this species is the one that is found in the coastal counties around and north of San Francisco on *Sequoia sempervirens*, the coastal big tree. It is a coppery-colored species to which Blaisdell first gave the manuscript name "*euprascens*" (specimens from Casadera in the California Academy of Sciences still bear a label with this name), but later Blaisdell named it after its food plant and called it *G. sequoiae*. The pubescence is not very conspicuous because it is usually brownish, like the beetle, sometimes paler brown or yellowish brown, but never really white, and it is silky and not at all coarse. On the middle part of the prothorax it appears nearly hairless, but the hairs here are even finer and sparser and usually darker. The aedeagus does not have so rounded a tip as in the Sierra species that have been up to now confused with the coastal *G. sequoiae*.

Glyptoscelis juniperi, new species

FIGURE 14

Between 6 and 8 mm. in length, oblong oval, shining with an aeneous or rosy glint under white or pale straw-colored pubescence, antennae and legs deep reddish brown, moderately coarsely and densely punctate.

Head with interocular space more than half width of head, a more or less distinct median line down front, finely punctate above, punctation becoming coarser in lower front, occiput thinly covered with brown pubescence, lower front with coarser white hairs; eyes emarginate at antennal sockets. Antennae long, slender, a bit wider in outer joints, extending below humeri, reddish brown. Prothorax extending slightly forward at anterior angle; moderately convex with nearly straight sides; depressed along base in middle; densely and deeply but not coarsely punctate, covered on sides with feathery yellowish or white pubescence, middle often with darker hairs. Scutellum with fine short white hairs. Elytra slightly depressed below scutellum, with a slight transverse depression below basal callosity and an intrahumeral sulcus; punctures not very coarse or dense with horizontal ridging near base; pubescence not so dense as to hide surface beneath entirely, uniform white or pale straw-colored hairs, sometimes intermingled with darker brown, moderately coarse. Body beneath densely punctate and covered with white pubescence. Length 6–8 mm.; width 3–4 mm.

Type: Male, and 87 paratypes, California Academy of Sciences, of which 15 paratypes are in the U.S. National Museum.

Type-locality: Fallen Leaf, Eldorado County, Calif., on *Juniperus occidentalis*, F. E. Blaisdell and Ralph Hopping.

Other localities: CALIFORNIA: Placer Co.: Angora Lake, Tahoe, June 22, 1915, Van Dyke; Glen Alpine, Nov. 24, 1915, Hopping and Van Dyke; Summit, July 1907, 7000 ft., Forest Hill, October 1898, Van Dyke. SIERRA Co.: Gold Lake, July 10, 1921, C. L. Fox. ELDO-RADO Co.: June 12, 1906, C. L. Fox; Meyers, July 3, 1916, E. C. Zimmermann; Echo Lake. NEVADA Co.: Chicago Park, June 5, 1936, J. W. Green; Carson City, June 25, 1929, R. L. Usinger; Graniteville, July 2, 1923, J. O. Martin.

Remarks: This Sierra species has been identified as *G. sequoiae* although the habitat as well as food plant are quite different. Both *G. sequoiae* and *G. juniperi* are about the same size and with similar sculpture, but their pubescence is different, giving them a different appearance. *Glyptoscelis sequoiae* is coppery, both in its lustre and

the fine brownish hairs that cover it. *Glyptoscelis juniperi* in its typical form often has an aeneous green or even rosy lustre, and the pubescence is not brown but white or straw colored. Only occasionally are there specimens with darker brown hairs intermingled on the elytra. On the occiput of the head the hairs are fine and dark, so that the top of the head appears quite dark. The aedeagus, too, differs from that of *G. sequoiae*, in being broadly rounded at the tip.

There is a series of specimens from Bijou, Lake Tahoe, and another series from Facht, Lassen County, and scattered specimens from other localities in Eldorado, Lassen, and Modoc Counties that are much darker in appearance, in fact, almost black, with little evidence of aeneous or bronzy lustre, and the pubescence on these is darker brown with scattered white hairs. The aedeagi appear to be no different from those of typical *G. juniperi*. One of these specimens was collected on *Pinus murrayana*. Whether these darker specimens represent a different subspecies or even another species is not clear. The aedeagus gives no clue of difference. These darker specimens are easily confused with a more northern species, *G. septentrionalis*, which also has dark elytral pubescence, but in *G. septentrionalis* the elytral hairs are denser and often less appressed, and the beetles have a bronzy lustre and the aedeagus is less rounded at the tip. In general it is a smaller, browner appearing species.

***Glyptoscelis juniperi zanthocoma*, new subspecies**

FIGURE 15

Between 6 and 8 mm. in length, oblong oval, shining with a coppery or aeneous lustre with reddish brown antennae and legs and with closely appressed dense yellowish brown, fine pubescence, pubescence on pronotum being finer and silky, deeply and not coarsely punctate.

Head with interocular space more than half width of head, eyes a little emarginate at antennal sockets; densely punctate, with lower front more coarsely punctate, a median line down front usually ending in a depression, covered with pale yellowish brown pubescence that is less or not at all over lower front. Antennae reddish brown, extending well below humeri, slender with the outer joints a bit widened, seventh joint long. Prothorax nearly as long as wide with slightly curved sides, moderately convex and depressed along base, deeply but not very coarsely or densely punctate and covered with long fine pale yellowish-brown hairs that are thicker in feathery swirls on the sides than in the middle. Scutellum with fine short hairs. Elytra slightly depressed below scutellum and with a short intrahumeral sulcus and slight transverse depression below basal callosity, punctation coarser near base and with horizontal ridging; surface only partially concealed by long, pale yellowish-brown pubes-

cence that is thicker along base and suture. Body beneath densely punctate and covered with pale yellowish-brown pubescence, legs, reddish brown. Length 6–7.8 mm.; width 3–4 mm.

Type: Male, California Academy of Sciences, and 15 paratypes, of which 5 are in the U.S. National Museum.

Type-locality: Huntington Lake, Fresno County, Calif.

Other localities: CALIFORNIA: Fresno Co.: Stevenson Creek, May 27, 1915, R. Hopping, collected on *Libocedrus decurrens*. Tuolumne Co.: Pine Crest, April 1934, E. P. Van Duzee; Long Barn, Apr. 20, 1934, E. P. Van Duzee. Calaveras Co.: Big Trees, May 11, 1935, F. E. Blaisdell. Amador Co.: Tin Rise, June 1, 1936. Mariposa Co.: Yosemite, June 25, 1910, J. O. Martin; Miami Ranger Sta., May 27, 1912, on *Libocedrus decurrens*, A. J. Waltz. Tulare Co.: on cedar, Atwoods Mill, May 29, 1913, Van Dyke; Sequoia National Park, 3000–5000 ft., June 11, 1929, A. T. McClay; California Hot Springs, June 3, 1939. Calaveras Co.: Big Trees, July 19, 1907, F. E. Blaisdell; Calaveras Grove, Apr. 17, 1934, Van Dyke. Inyo Co.: Westgard Pass Plateau, June 15, 1937, Van Dyke.

Remarks: This may be a distinct species in itself, although it is not very clear cut. Its food plant as recorded several times is not *Juniperus* but *Libocedrus decurrens*. Its range generally appears to be more southern in the Sierras than typical *G. juniperi*. In appearance the beetles look yellowish brown because of the long yellowish pubescence in contrast to typical *G. juniperi*, in which the general effect is of an aeneous or even rosy-lustred beetle lightly covered with white or straw-colored pubescence. There is a slight difference in the aedeagus too, that of the typical form being more widely rounded. And the claw has an inner tooth located slightly lower than in the typical form. On the other hand, there are specimens that intergrade so that I cannot come to any conclusion as to which group they belong.

Glyptoscelis longior Le Conte

FIGURES 21, 23

Glyptoscelis longior LeConte, 1878, Bull. U.S. Geol. Surv., vol. 4, no. 2, p. 262.—

Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, pp. 26, 27.

Glyptoscelis albida Horn, 1892, Trans. American Ent. Soc., 19, p. 203.

Between 5.5 and 6.8 mm. in length, elongate oblong oval, shining piceous with a very faint bronzy lustre, densely punctate and with dense, closely appressed, coarse white hairs mixed with very pale brownish hairs to produce a grayish appearance; prothorax convex with nearly straight sides.

Head with a median depressed line from occiput down front, punctation over occiput finer and with fine dark hairs, on lower front punctation becoming coarser and denser with coarse white hairs.

Antennae reddish brown. Prothorax convex, usually with nearly straight sides; punctures deep, well separated and becoming coarser towards middle and base; pubescence coarse and closely appressed, with white and pale brown hairs intermingled. Scutellum broad, with finer hairs. Elytra with prominent humeri, a well-marked intrahumeral depression and a slight umbone between it and depression below scutellum; punctation not too dense or coarse, with some ridging and covered with dense, appressed white and pale brownish hairs producing a gray appearance. Body beneath densely covered with a little finer gray pubescence. Length 5.5–6.8 mm.; width 1.7–3.5 mm.

Type: Female, Museum of Comparative Zoology.

Type-locality: Atlanta, Idaho, collected by O. Reinecke.

Other localities: OREGON: Durkee, June 17, 1941, K. M. Fender; Baker, 1940, M. C. Lane; Bend, Tumalo State Park, June 23, 1954, K. M. Bender; Burns, May 5, 1941, M. C. Lane; Bly, June 15, 1945, K. M. Bender; Ironsides, May 21, 1941, M. C. Lane; Sucker Creek Canyon, Malheur Co., June 15, 18, Borys Malkin; Sisters, Deschutes Co., June 13, 1951, Borys Malkin, on juniper; Lakeview, June 27, 1955; Borys Malkin; Lake of Woods, Klamath Falls, K. M. Fender; French Creek, Harney Co., June 21, 1951, Borys Malkin; Pueblo Mts., Harney Co., May 22, 1950, K. M. Fender; Steene Mts., Fish Lake, June 22–26, 1951, Borys Malkin; Mayville, June 21, 1938, M. H. Hatch; Bear Springs, Wapinita Cutoff, June 30, 1941, K. M. Fender; Umatilla Co., Emigrant State Park, June 19, 1938, M. H. Hatch. IDAHO: Hyndman Creek, Challis, N. F. Blaine; Caldwell, May 8, 1921, alt. 2367 ft. WYOMING: Grand Teton National Park, June 21, 1930, Van Dyke; Yellowstone Park, June 28, 1907, W. Robinson; Jenny Lake, Grand Teton National Park, June 24, 1938, Van Dyke.

Remarks: The gray appearance of these slender little beetles is the most noticeable character. The pubescence is dense, coarse, and of mixed white and very pale brownish hairs, and also covers the surface below, obscuring any lustre such as is evident in *G. septentrionalis*. The range of this species is more limited than that of *G. septentrionalis*, as it has not been found north of Oregon, and there only from the middle of the state eastward into southern Idaho and north-west Wyoming. There is only one record of its food plant, and that is of its being taken on juniper.

This species has been rather generally misidentified in collections possibly because Horn synonymized it with *G. albida* LeConte, which is a larger, more robust species and does not occur north of California. The type of *G. longior* is badly rubbed with little pubescence left, and since the pubescence in this genus is usually a good character in

separating the species, its lack makes it more difficult to understand. There are three small species of about the same size occurring in the northwest states. One, *G. artemisiae*, has a shorter and differently shaped prothorax. The other, *G. septentrionalis*, has a more bronzy lustre than *G. longior*, and generally, but not always, the prothorax has more rounded sides, and the pubescence is usually dark brown on the elytra.

Glyptoscelis coloradoensis, new species

FIGURE 24

Between 6 and 8 mm. in length, oblong oval, piceous shining with a bronzy lustre, antennae reddish brown; prothorax and elytra not too densely or coarsely punctate and covered with dense coarse white and pale yellowish-brown hairs.

Head with interocular space more than half width of head, eyes emarginate at antennal sockets, a median line down front ending in a depression, densely and moderately finely punctate over occiput with lower front more coarsely punctate; hairs on occiput yellowish and finer, becoming coarser and white on lower front. Antennae long and slender with the outer joints a little wider. Prothorax slightly wider than long, convex with very slightly rounded sides, punctures anteriorly fine, becoming coarser and more oval in shape near base; pubescence thick, in middle tending to be yellowish, very feathery and white on sides. Scutellum with finer hairs. Elytra slightly depressed below scutellum, a short intrahumeral sulcus, punctuation not very coarse, near base horizontally ridged; pubescence thick and coarse, some pale yellowish-brown hairs intermixed, not closely appressed but somewhat erect. Body beneath densely punctate and covered with densely, closely appressed white hairs. Length 6-7.8 mm.; width 2.8-4 mm.

Type: Male, and 35 paratypes, California Academy of Sciences, 10 of these in the U.S. National Museum.

Type-locality: Paonia, Delta County, Colo., collected by E. C. Van Dyke, June 14, 1926.

Other locality: UTAH: Mt. Carmel, near Zion Canyon, May 30, 1935, E. C. Van Dyke.

Remarks: Krauss has identified this as *G. longior* LeConte, and it is very similar in size and pubescence but has a wider prothorax and the aedeagus has a well-rounded apex with a small, very inconspicuous nodule at the tip, quite unlike the aedeagus of *G. longior*.

Glyptoscelis septentrionalis, new species

FIGURE 22

Between 6 and 8 mm. in length, oblong oval, deep brownish black, shining with a bronzy lustre beneath a rather coarse, dense, and

dark brown and white pubescence, the white hairs being more pronounced along base and suture of elytra; punctation on prothorax dense, deep, often oval; on elytra not quite so dense, surface somewhat ridged below intrahumeral sulcus.

Head rather finely punctate over occiput with a median line ending in a depression in middle of front, more coarsely punctate on lower front; pubescence over occiput dark, fine, and not conspicuous, over lower front with coarser and white hairs; labrum tending to be reddish brown. Antennae rather long, reaching nearly to middle of elytra, deep reddish brown. Prothorax convex with nearly straight sides, only slightly rounded, densely and deeply punctate, punctures finer near anterior margin, pubescence in median area with finer and denser hairs, and on sides with more conspicuous, coarser, denser brown and white hairs. Scutellum with fine unusually dark hairs. Elytra slightly depressed below scutellum, punctation not as dense or coarse as on prothorax, somewhat ridged below intrahumeral sulcus; pubescence rather long and coarse, usually with more dark brown than white hairs, white hairs usually along basal margin and suture. Body beneath densely covered with a grayish, not pure white, sometimes even pale brownish pubescence. Length 6-8 mm.; width 2.8-4 mm.

Type: Male, USNM no. 69197 and 52 paratypes, 20 of which are in the U.S. National Museum, remainder in collection of University of Washington.

Type-locality: Diamond Lake, Douglas County, Oreg., June 24, 1941, K. M. and D. M. Fender.

Other localities: CALIFORNIA: Bair's Ranch, Redwood Creek, Humboldt Co., June 13, H. S. Barber. OREGON: McMinnville; Josephine Co., June 11, 1910; Grant's Pass. Apr. 28, 1934, F. M. Beer; Wimer, June 24, 1958, F. M. Beer; Tygh Valley, May 30, 1938; Mt. Hood, 5000-6000 ft., June 26, 1925, Van Dyke; Crater Lake, July 12, 1937, J. W. Green; alt. 7000 ft., July 16, 1939, M. C. Lane, on fir; Lake of Woods, Klamath Falls Rd., K. M. Fender; Meacham, May 22, 1935, M. C. Lane; Wallowa Lake, June 22, 1941, K. and D. Fender; Toll Gate Rd., Blue Mts., June 10, 1938, Van Dyke, Van Duzee; Blue Mts., July 16, 1933, M. C. Lane; Steen Mts., Harner Co., July 2, 1922, Van Dyke; mountains west of LaGrange, July 25, 1922, Van Dyke. WASHINGTON: Tacoma, May 15, 1945, M. J. Forsell; Shelton, May 25, 1935, on *Pinus contorta*, R. L. Furness; Lake Cle Elum, Apr. 27, 1939, Hatch and Wilson; Easton, June 14, 1930, W. W. Baker; June 10, 1938, M. C. Lane; Mt. Ranier; Pelous, Kamiak Butte, May 24, 1935, M. C. Lane; Newman Lake, June 11, 1922, M. C. Lane; Skamania Co., Little Huckleberry Mt., July 15, 1937, Jack Price; Mt. Adams, 6000-7000 ft., July 2, 1925, Van Dyke,

Bird Creek, Mt. Adams, July 2, 1925, Van Dyke; Walla Walla, May 13, M. C. Lane; June 20, 1941, K. and D. Fender; Blue Mts., Lewis Park, June 20, 1941, K. M. Fender; June 18, 1945, 4500 ft., M. C. Lane; Blue Mts., Blacksnake River, June 25, 1941, M. C. Lane; Republic, May 7, 1930, G. R. Hopping; Wawawai, Apr. 17, 1931, feeding on cherry; Pullman, June 8, 1901, C. V. Piper; Govan, Lincoln Co., W. S. Abbott, in *Phrynosoma* (horned toad). IDAHO: Coeur d'Alene, May 5, 1920, J. S. Evenden, on *Pinus ponderosa*; Moscow, May 30, 1920, alt. 3200 ft., W. E. Shull. MONTANA: Sula, June 24, 1929, alt. 4700 ft., W. E. Shull. BRITISH COLUMBIA: Vernon, May 13, 1926, R. Hopping; North Bend, June 6, Hubbard and Schwarz.

REMARKS: Although apparently this is one of the most common species of *Glyptoscelis* in the Pacific Northwest, it has never been recognized as a species different from those already described, but has been confused with either *G. sequoia*, a more southern species living on *Sequoia sempervirens*, or with *G. albida*, which does not extend into Oregon or Washington either, and is a larger, more robust beetle. There are several records of *G. septentrionalis* being taken on "fir," one on *Pinus contorta* and one on *P. ponderosa*. It has a quite different aspect from *G. sequoiae*, which is a very lustrous coppery beetle with pubescence that varies from yellowish to brownish but is never white. In contrast, *G. septentrionalis* is piceous, shining with a bronzy lustre, and the coarse pubescence on the elytra in particular is usually dark brown with scattered white hairs. Its range is from northern California to British Columbia, and eastward through Idaho into Montana.

***Glyptoscelis artemisiae*, new species**

FIGURE 18

From 6 to 7 mm. in length, oblong oval, shining bronzy black under coarse white pubescence, pubescence on elytra forming more or less distinct white vittae, giving it a striped appearance; prothorax coarsely and densely punctate, elytra not so coarsely but densely punctate; aedeagus truncate and not rounded at apex.

Head with interocular space more than half width of head, eyes slightly emarginate at antennal sockets, a median line down front ending in a depression, densely punctate, lower half more coarsely so, covered with white pubescence that is finer on occiput. Antennae extending below humeri, slender, outer joints somewhat thicker, seventh joint long, reddish brown to piceous. Prothorax wider than long with nearly straight sides, convex, depressed along base; densely and coarsely punctate and covered with coarse pubescence that in middle tends to be pale brownish, white along sides. Scutellum with a few finer white hairs. Elytra with prominent humeri, deep intra-humeral sulcus, a small basal callosity with depression below, a little

depressed below scutellum; punctation coarser near base with some horizontal ridging, becoming finer towards apex, covered with pale brown and white pubescence, coarse and closely appressed, and in most specimens with vittate lines of thicker white hairs giving it a striped appearance. Body beneath densely punctate and covered with closely appressed white pubescence, tibiae and tarsi deep reddish brown. Length 6-7 mm.; width 3-4 mm.

Type: Male, and 9 paratypes, U.S. National Museum type no. 69198.

Type-locality: Sardis, Wash., taken on sagebrush, May 21, 1899.

Other localities: WASHINGTON: Washington Experiment Station, W. S. Abbott, 1932; Ewan, June 28, 1920, R. C. Shannon; Lind, May 15, 1922, M. C. Lane; Washington Territory, J. B. Smith; Ritzville, May 6, 1921, M. C. Lane; Grand Coulee, Dry Falls Lake, Apr. 21, 1957, M. H. Hatch; Upper Grand Coulee, Apr. 26, 1936, M. H. Hatch; Moses Coulee, Apr. 4, 1947, George Schenk; Dry Falls, May 14, 1938, M. H. Hatch; Pullman, C. V. Piper, M. C. Lane; Vantage, May 4, 1935, Hatch and Wilson; Kahlatus, Sandhills, Apr. 18, 1955, M. H. Hatch; Kaniak Butte, May 7, 1935; Cheney, May 24, 1940; Kittitas, May 4, 1935, Hatch and Wilson; Roza, Kittitas Co., May 19, 1957, M. H. Hatch; Uniontown, May 20, 1939, M. C. Lane; Euphrata, Apr. 19, 1935, M. H. Hatch; Prosser, Apr. 25, 1911; Tieton, Yakima Co., Ewan; Almoto, Wawawai; Yakima Co., April 29, 1919, on sagebrush, E. J. Newcomer; Republic, May 7, 1936, G. R. Hopkins. OREGON: Baker Co., July 1922. BRITISH COLUMBIA: Okanagan Falls, E. S. Ross; Spious Creek, May 28, 1920, R. Hopping; Vernon, May 2, 1932, R. Hopping; Wardner, May 13, 1927, A. A. Denays. IDAHO: Juliaetta, J. M. Aldrich. ALBERTA: Medicine Hat, June 26, 1927, F. S. Carr.

Remarks: This small species has been taken by several collectors on sagebrush. It has been in the past identified as *G. longior* LeConte by Krauss and *G. albida* LeConte by others, but it is a distinct little species easily identified by the squarely truncate apex of the aedeagus and the white vittate pattern in the elytral pubescence. As in *G. albida* the pubescence is coarse and white. It is one of the two most northernmost of our species of *Glyptosecelis* and it ranges from northeast Oregon and northern Idaho throughout eastern Washington to British Columbia and Alberta. The other most northern species, *G. septentrionalis*, has a wider, more southern as well as coastal range, from Humboldt County in the northwestern part of California, throughout Oregon and Washington to British Columbia. It also ranges eastward in Idaho and there is one record of its occurrence in Montana. This species has been recorded on "fir" trees. It has a distinct bronzy lustre in contrast to the shining black of *G. artemisiae*, and

usually the elytra are covered with thick brownish pubescence with some white hairs intermingled. There is a third northern species, *G. longior* LeConte, whose type-locality is Atlanta, Idaho, and which does not extend north of Oregon but is found also in Wyoming in the Yellowstone National Park area. All three species are small and easily confused and from essentially the same northwestern area.

***Glyptoscelis paula*, new species**

FIGURE 19

About 6 mm. in length, elongate oblong oval, shining piceous beneath coarse white pubescence. Antennae and tarsi reddish brown, claw with inner tooth near tip making it appear bifid.

Head with interocular space slightly more than half width of head, eyes emarginate at antennal sockets, occiput very finely and sparsely punctate, more coarsely punctate on lower front with coarser white pubescence, a median line ending in a depression in middle of front. Antennae extending below humeri, reddish brown. Prothorax almost as long as wide with nearly straight sides, convex, moderately densely and not coarsely punctate, with finer white hairs than on elytra. Elytra with prominent humeri and an intrahumeral sulcus and faintly depressed area about scutellum, rather finely and not densely punctate and not too densely covered with coarse white and pale brown hairs. Body beneath densely pubescent. Length 6 mm.; width 2.7 mm.

Type: Male, U.S. National Museum no. 69199.

Type-locality: Wendell, Idaho, May 19, 1933, "on pure stand of *Artemisia tridentata*."

Remarks: The slender shape and small size of this species distinguish it from *G. parvula* Blaisdell and *G. coloradocensis*. Like both of them the claw has an inner tooth near the tip and the aedeagus like them has a rounded apex. The head in *G. paula* is unusually smooth and with punctures only along the median line on the occiput and front, and in this respect it differs from the other species, which are all densely and coarsely punctate over the entire head. In its slender shape as well as its faintly vittate elytral pubescence, it resembles *G. artemisiae*, another small species, but the aedeagus in *G. artemisiae* is truncate and not rounded at the tip. Only one specimen is known.

***Glyptoscelis parvula* Blaisdell**

FIGURE 25

Glyptoscelis parvulus Blaisdell, 1921, Stanford Univ. Publ. Biol. Ser., vol. 1, no. 3, pp. 196-7.

Glyptoscelis parvula Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, pp. 28-29.

Between 5 and 7 mm. in length, elongate oblong oval, shining, dark piceous beneath moderately coarse but not dense white and pale brown

pubescence, legs and antennae reddish brown, prothorax convex, widest at middle and narrowed at base, densely punctate.

Head with median line ending in a depression in middle of front, densely punctate, punctures in lower front coarser, covered with white appressed hairs, eyes a little emarginate at antennal sockets, labrum reddish brown. Antennae extending below humeri, outer joints considerably thicker, reddish brown deepening to dark brown, covered with fine white pubescence. Prothorax convex but depressed along base, widest at middle, contracted at base, punctuation deep, dense, elongated, rather sparsely covered with white and often pale brown hairs. Scutellum with finer hairs. Elytra with a slight depression about scutellum and another below basal callosities, in which punctures show horizontal ridging, punctures deep, not very close and becoming finer towards apex; pubescence not so dense as to hide completely punctures, of mingled pale brown and white moderately coarse hairs, giving a pepper and salt appearance. Body beneath densely punctate with dense, white, closely appressed pubescence. Legs reddish brown, claw joint with inner tooth near apex, giving it a bifid look. Length 5-7 mm.; width 2.6-3.6 mm.

Type: Male, in California Academy of Sciences.

Type-locality: Sacramento, Calif., collected May 28, 1918, on willow by E. P. Van Duzee.

Other localities: CALIFORNIA: Sacramento Co.: Courtland, May 6, 1920, F. H. Wymore; Michigan Bar, Apr. 24, 1922, E. G. Thompson. Solano Co., Rio Vista, May 25, 1926. Alameda Co.: Piedmont, May 23, 1921. Butte Co.: near Butte Creek, Chico, Apr. 25, 1922, E. P. Van Duzee. Tehama Co.: Los Molinos, Apr. 1, 1932, on *Salix*, E. F. Wohlet; also taken at Sacramento by E. H. Wohlet on wild rose, and by Helen Van Duzee, Apr. 24, 1922, A. T. McClay, Apr. 3, 1936, C. M. Packard, Apr. 26, 1920.

Remarks: This is one of the smallest species of *Glyptoscelis* in the United States, comparable in size to *G. paula*, which occurs in Idaho on *Artemisia*. *Glyptoscelis parvula* is more rounded and less elongate and has thicker antennal joints. It has been collected on willow and wild rose and seems to be confined to the counties about Sacramento, its type-locality.

Glyptoscelis illustris Crotch

FIGURE 17

Glyptoscelis illustris Crotch, 1873, Proc. Acad. Nat. Sci. Philadelphia, p. 35.—Horn, 1892, Trans. American Ent. Soc., vol. 19, p. 262.—Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 23.

Between 9 and 11.5 mm. in length, elongate oblong oval, lustrous, bronzy black, strongly punctate and with brown and white pubescence,

the white hairs being coarser and forming a pattern on elytra along suture and sides and two vittate white lines in apical half, the brownish hairs finer and more silky; elytra with a marked depression below scutellum and also a deep one below basal callosities.

Head with interocular space much more than half width of head, eyes with small emargination at antennal sockets, a well-marked and usually indented median line down front ending in a slight depression; punctation dense, moderately coarse and becoming coarser in lower part, pubescence over front brown, around eyes and mouthparts white. Antennae extending well below humeri, rather slender without much thickening of apical joints, seventh joint long, all reddish brown. Prothorax nearly as long as wide with rounded sides curving forward about eyes, disc convex, without depressions, very shiny, deeply and moderately coarsely punctate, punctures tending to be elongate and in middle often disappearing, leaving a linear median bare area, sometimes a depression on either side near lateral edge and below middle, from which pubescence radiates; pubescence over middle very fine, silky and brown, over sides becoming coarser and white. Scutellum with a few fine brown hairs. Elytra with well-marked humeri and intrahumeral sulcus, widely depressed around and below scutellum, a basal callosity and below it a transverse depression; surface very lustrous, often with rosy or coppery lights, not too densely and moderately coarsely punctate, without horizontal ridging, punctures becoming finer toward apex; pubescence forming a pattern with coarser white hairs along base, suture and in short vittae below middle and along sides, with a widening at middle, rest of surface with inconspicuous silky brown hairs not very dense or obscuring surface. Body beneath densely punctate and evenly covered with white appressed hairs; legs deep reddish brown, hairs at apex of tibiae long, silky, and brownish in color. Length 9–11.7 mm.; width 4.5–5.5 mm.

Type: Male, in Museum of Comparative Zoology. There are three specimens, the first two labelled "Calif." and the third without a label.

Type-locality: Crotch gives "California (Horn) and Oregon (Walsingham)."

Other localities: OREGON: A. T. McClay, July 11, 1938; Klamath Falls, July 8, 1934, Van Dyke; Grant's Pass, on *Pinus ponderosa*, Apr. 24, 1949; Prospect, June 14, 1941, L. G. Gentner. CALIFORNIA: Kernville, Dec. 28, 1936; Bear Flat, Warner Mts., Modoc Co., July 10, 1919, on *Pinus ponderosa*, Ralph Hopping; Mokel Hill, F. E. Blaisdell; Carrville, Trinity Co., alt. 2400–2500 ft., Van Dyke; Forest Hill, Placer Co., April 1898, on *Pinus ponderosa*, Van Dyke; Stevenson Creek, Sierra National Forest, May 27, 1915, on *Pinus ponderosa*, Ralph Hopping; Nevada City, May 16, 1930, E. P. Van Duzee; Davis Meadow, R. R. Flats, 2800 ft., July 8, 1907, F. E. Blaisdell;

Bass Lake, Madera Co., Apr. 24, 1934, H. P. Allen; Sonora, Tuolumne Co., Apr. 17, 1934, E. P. Van Duzee; Pyramid, Ranger Sta., F. B. Herbert, on *Juniperus occidentalis*.

Remarks: The large size, lustrous bronzy coloring and silky brown pubescence mingled with the coarser white hairs that form a vittate pattern at the apex of the elytra distinguish this species.

Glyptoscelis aridis Van Dyke, new status

FIGURE 16

Glyptoscelis illustris ssp. *aridis* Van Dyke, 1938, Ent. News, vol. 49, p. 194.

From 8 to 10.5 mm. in length, oblong oval, shining bronzy black beneath the coarse white and yellowish-brown pubescence; prothorax nearly as long as wide, densely and coarsely punctate with yellowish-brown pubescence in middle and white hairs on sides; elytra nearly covered with dense coarse white hairs with yellowish-brown hairs forming short vittae, especially in apical half; somewhat depressed about scutellum and a shallow transverse depression below basal callosities; punctation on pronotum deep, round, not too coarse, and on elytra becoming finer toward apex.

Head with interocular space more than half width of head, surface densely punctate, more coarsely on lower half, covered with thick white pubescence and across front with light yellowish-brown thick hairs, a median line ending in a small depression on front. Antennae extending below humeri, dark reddish brown with white pubescence, seventh joint long. Prothorax somewhat wider than long with rounded sides, shining, deeply, densely, but not coarsely punctate, sides well covered with coarse white pubescence, in middle less densely by yellowish-brown pubescence. Scutellum with many white hairs. Elytra with prominent humeri, a short intrahumeral sulcus, a depressed area about scutellum and below basal callosities; surface shining beneath coarse, semierect hairs that are mostly white but with yellowish-brown hairs on basal callosities and in vittate areas near apex; punctation moderately coarse and dense, with little horizontal ridging, becoming finer toward apex. Body beneath uniformly covered with white appressed pubescence, the hairs near apex of middle and hind tibiae becoming yellowish. Length 8-10.5 mm.; width 4.5-5.1 mm.

Type: In California Academy of Sciences.

Type-locality: Westgard Pass Plateau, Inyo County, Calif., taken May 27, 1937, Van Dyke collector, June 7, 1937, L.D. Phillips.

Other localities: CALIFORNIA: Argus Mts., Inyo Co., on *Pinus monophylla* Voss, Hubbard and Schwarz, May 1891.

Remarks: Although Van Dyke regarded this as a subspecies of *G. illustris*, there is sufficient difference in the pubescence as well as

the aedeagus to make it a distinct species. In its general appearance it is a much paler beetle due to its coarse and dense white pubescence, in which the brown hairs are coarser and fewer than are those of *G. illustris*. There is very little elytral surface to be seen because of this dense pubescence, whereas in *G. illustris* the shining, even coppery, surface is very apparent.

***Glyptoscelis cylindrica*, new species**

FIGURE 20

About 7 mm. in length, elongate oblong oval, almost cylindrical, shining black, densely and coarsely punctate and with a very fine erect yellowish or grayish hair from each puncture, hairs on under-surface more appressed, legs and antennae deep reddish brown.

Head with interocular space considerably more than half width of head, eyes with tiny emargination at antennal socket, occiput and front coarsely and contiguously punctate, a small depression in middle of front, a semierect fine silken hair from each puncture, head shiny piceous except for reddish-brown labrum. Antennae extending slightly below humeri, basal joint globular, joints two to five thinner than outer joints, seventh joint long. Prothorax as wide as elytra and approximately as wide as long, strongly convex, sides rounded, disc slightly depressed along base, punctures dense and each with a fine hair. Scutellum unusually broad and short, punctate. Elytra deeply and almost contiguously punctate, each puncture with a long, erect, silky pale hair, producing a fuzzy effect, humeral prominences lacking (probably a wingless beetle), otherwise without depressions. Body beneath shining, slightly less coarsely punctate, the pale pubescence more appressed but not coarser; legs reddish brown, covered with long, semierect pale hairs, tibiae rather short. Length 6.8 mm.; width 3.1 mm.

Type: ?female, in California Academy of Sciences.

Type-locality: Cotati, Sonoma County, Calif., May 5, 1948, E. H. Calkins.

Remarks: This is the most aberrant in appearance of any species of *Glyptoscelis*, yet it is undoubtedly of that genus. The fuzzy silky hairs that are not appressed but erect, and the lack of humeral prominences are its most distinctive characters. Otherwise it resembles other species of the genus with its coarsely punctate dark surface, its sulcate tibiae and toothed claws. Only one specimen is known. That the beetle probably is wingless doubtless explains the limitation of its distribution.

***Glyptoscelis prosopis* Schaeffer**

FIGURE 26

Glyptoscelis prosopis Schaeffer, 1905, Bull. Brooklyn Mus., vol. 1, no. 7, p. 169.—Krauss, 1937, Univ. California Publ. Ent., vol. 7, no. 2, p. 25.

From 7 to 9 mm. in length, elongate oblong oval, elytra shining with a bronzy lustre, legs and antennae deep reddish brown, covered with fine white pubescence, pattern of pubescence on pronotum with hairs parting in middle and falling in feathery pattern downward, and on the sides arranged more horizontally; punctation shallow, often contiguous, in some specimens remnants of a bare median line; elytral punctation not so dense, pubescence a bit coarser.

Head with interocular space more than half width of head, eyes with a small emargination at antennal sockets, finely and densely punctate and covered with white pubescence, sometimes a median bare line; labrum reddish brown. Antennae extending below humeri, apical joints widened, seventh joint long, reddish brown, the apical joints often deep brown. Prothorax not much wider than long, strongly convex, with a decided convexity in middle, sides slightly rounded, punctation dense, shallow, in places coarse and often a remnant of bare line down the middle; pubescence white, fine, and arranged in feathery pattern from middle, not horizontally but downward, becoming more horizontal on sides. Scutellum broad and rather short, with a few fine white hairs. Elytra elongate, not much wider than prothorax, with well-marked intrahumeral depression, no depression near scutellum but a slight transverse one below intrahumeral sulcus; punctation coarse, not so dense as on pronotum and covered rather densely by moderately coarse, closely appressed long hairs; considerable horizontal ridging in basal half on disc. Body beneath covered with coarser and denser white hairs, legs reddish brown. Length 7-9 mm.; width 3.2-4.3 mm.

Type: In U.S. National Museum, with 2 paratypes.

Type-locality: Esperanza Ranch, Brownsville, Tex. Also collected at Brownsville, June 25, 1930, by J. O. Martin, and taken on a plane at Brownsville, June 24, 1948.

Remarks: This species differs from the other United States species of *Glyptoscelis* and resembles many species from Mexico and Central America and even South America by having remnants of a median bare line on the pronotum. It differs from *G. mexicana* Jacoby in having a lustrous and not dull opaque surface. There is no prolongation at the tip of the elytra.

Key to Mexican and Central American Species of *Glyptoscelis*

1. Elytra with tips narrowly prolonged 2
 Elytra with tips not prolonged 3
2. From 8 to 10 mm. in length with long tip to elytra (Nicaragua).

chontalensis Jacoby

About 7.5 mm. in length with shorter tip to elytra (Guatemala).

guatemalensis, new species

3. Prothorax without median bare line, surface dull opaque black.
Prothorax with median bare line *mexicana* Jacoby 4
4. Elytral punctures fine and tending to be in double rows, widely separated by bare intervals *cahitae*, new species
Elytral punctures denser and coarser *sonorensis*, new species

Glyptoscelis sonorensis, new species

FIGURE 27

From 6 to 8 mm. in length, elongate oblong oval, shining dark reddish brown to piceous, antennae and legs pale reddish brown; prothorax with remnants of a median impunctate line, densely and not coarsely punctate; elytra with small humeri, narrow, not much wider than prothorax, a slight transverse depression below scutellum, elytral punctation not so dense as on prothorax, white patches of denser hairs in places.

Head with interocular space slightly more than half width of head, a median bare line down front, punctures not very dense or coarse beneath the closely appressed white pubescence. Antennae extending below humeri, reddish brown. Prothorax nearly as wide as elytra, wider than long, not so convex as in *G. prosopis*, a median impunctate line, otherwise with dense and rather fine punctation; pubescence arranged in feathery downward-falling pattern from median line, becoming more horizontal on sides. Scutellum with a few finer white hairs. Elytra with weak humeri and short intrahumeral sulcus, a slight transverse depression behind scutellum, elytral punctation not so dense as on prothorax with some ridging, pubescence white, thick, with patches of denser hairs arranged in lines sometimes present. Body beneath thickly covered with white pubescence. Legs reddish brown. Length 6.3–7.8 mm.; width 3–3.8 mm.

Type: Male, California Academy of Sciences, and 24 paratypes, of which 6 are in the U.S. National Museum.

Type-locality: Alamos, Sonora, Mexico, Aug. 1, 1940, R. P. Allen.

Remarks: This species closely resembles *G. prosopis* Schaeffer from Brownsville, Tex., but has a less bulging occiput, a more marked median bare line down the pronotum, less marked elytral humeri, and the inner tooth on the claws is farther down near the base. The elytral pubescence of the Sonoran species usually shows thicker patches of white than is present in the Texas species, and the pubescence over the head and pronotum is coarser than in *G. prosopis*. The two species are very similar except for these minor differences.

Glyptoscelis cahitae, new species

FIGURE 29

From 7.5 to 9 mm. in length, oblong oval, somewhat shiny, piceous, antennae and sometimes tibiae and tarsi deep reddish brown; prothorax densely and shallowly punctate with well-marked median bare line, elytra with rather fine punctation tending to be geminate striate, some ridging near base and bare lines parallel to suture in apical half; white pubescence on prothorax fine and thick, coarser on elytra with some denser white patches in rows.

Head with interocular space approximately half width of head, a median bare impunctate line down front, a little swollen or ridged in middle of front, and with fine, thick, closely appressed white pubescence. Antennae extending slightly below humeri, basal joint dark, remainder slightly paler and usually deep reddish brown, the outer joints somewhat thickened. Prothorax wider than long with curved lateral sides, moderately convex and nearly as wide as elytra; a prominent bare median vertical line, on each side of which dense, shallow punctures with fine dense white pubescence arranged in a pattern away from median line toward base, and more horizontally toward sides near sides. Scutellum with a few white hairs. Elytra not much wider than prothorax, with small, not prominent humeri and very little intrahumeral sulcus; punctation rather fine, some horizontal ridging near scutellum and below humeri; punctures tending to be in double rows with bare intervals particularly near apex and suture. Body beneath with white pubescence, thicker on sides of metathorax; tibiae and tarsi sometimes not quite so dark piceous as femora. Length 7.5–9 mm.; width 3.5–4.4 mm.

Type: Male, in California Academy of Sciences, and 23 paratypes, of which 6 are in U.S. National Museum.

Type-locality: Los Mochis, Sinaloa, Mexico, collected in June and July 1922 by C. T. Dodds.

Other locality: Yaki Valley, Mexico, A. W. Morrill, Feb. 8, 1922.

Remarks: This is the third species of a group made up of *G. prosopis* Schaeffer from Brownsville, Tex., *G. sonorensis* from Sonora, Mexico, and the present one, *G. cahitae*, which differs from the other two by being generally wider and more robust in appearance. Like the Sonoran species this one differs too from *G. prosopis* in having inconspicuous humeri. The elytral punctation is different from both the others in that the punctures are more widely separated with bare intervals especially noticeable in the apical half. As in the Sonoran species the claw is toothed nearer the base than in *G. prosopis*.

Glyptoscelis mexicana Jacoby

FIGURE 28

Glyptoscelis mexicana Jacoby, 1882, in *Biologia Centrali-Americana*, Coleoptera, vol. 6, pt. 1, p. 177.

Between 7 and 9 mm. in length, elongate oblong oval, alutaceous, not at all shiny, dull piceous black with fine white pubescence, legs and antennae deep reddish brown, prothorax densely and almost contiguously, shallowly, and not coarsely punctate, elytra with punctures not quite so dense and also shallow and not very coarse, with white pubescence that in type is rubbed off except about sides. Each elytron acute at tip but not noticeably prolonged.

Head with interocular space about half width of head, front densely and shallowly punctate under the appressed white pubescence, a median occipital depression. Antennae reddish brown, extending below humeri. Prothorax somewhat wider than long, smoothly convex, without depressions, with well-rounded sides, no median ridge or line, punctures shallow, dense, finer anteriorly becoming coarser and more contiguous in middle and towards base, pubescence so rubbed that no pattern is visible. Scutellum with fine punctures and pubescence. Elytra convex with sharp humeral prominences, and a short, deep intrahumeral sulcus, a slight basal callosity on each side of scutellum with a transverse depression below; punctation not so dense as on prothorax but similar in being shallow and not very coarse, becoming finer and not so dense towards apex; pubescence appressed, in type specimen rubbed off except about edges. Body beneath covered with dense white coarse hairs. Length 7.5–9 mm.; width 2.6–3.2 mm.

Type: Museum of Comparative Zoology, Cambridge, Mass. Cotype in British Museum (Natural History).

Type-locality: Playa Vicente (Oaxaca) Mexico, Sallé collection.

Remarks: Jacoby wrote that he had two specimens; one is in the Bowditch collection, the other in the British Museum (Natural History). I have seen no other specimen from Mexico or Central America like them with their dull, opaque upper surface. The elytra are acute at the tip but not prolonged.

Glyptoscelis chontalensis Jacoby

FIGURE 30

Glyptoscelis chontalensis Jacoby, 1882 in *Biologia Centrali-Americana*, Coleoptera, vol. 6, pt. 1, p. 176.

From 8 to 10 mm. in length, elongate oblong oval, with prolonged tip to elytra, shining piceous beneath the long white appressed

pubescence, prothorax finely punctate with a median bare impunctate line, from which a transverse pubescence; elytra more coarsely punctate with horizontal ridging.

Head with interocular space a little more than half width of head, a median bare line down front, eyes emarginate at antennal sockets, punctation dense and becoming coarser in lower part under a dense white pubescence, labrum reddish brown. Antennae reddish brown, with outer joints often darker, extending below humeri, outer joints wider, seventh joint long. Prothorax wider than long, strongly convex, lateral sides curved and anteriorly projecting around eye; a median bare line and some round bare spots on disc, otherwise densely and rather finely punctate, a fine white pubescence extending from median line horizontally, and often thicker on sides. Scutellum shining piceous with a few white hairs. Elytra widest at humeri, tapering toward apex, where sides are pinched in and end in a sharp prolonged tip, not divergent; not depressed about scutellum but evenly convex, a short intrahumeral sulcus, humeri prominent; punctation coarser than on pronotum and not so dense with horizontal ridging between rows of punctures, sometimes a bare line parallel to suture near apex; surface shining with a bronzy lustre and thinly covered with pale appressed pubescence. Body beneath with thick white pubescence, especially heavy on sides, legs dark reddish brown. Length 8-10 mm.; width 3.6-4.5 mm.

Type: In Museum of Comparative Zoology, Cambridge, Mass. Cotype in British Museum (Natural History).

Type-locality: Chontales, Nicaragua, T. Belt collector.

Other localities: SALVADOR: Metapan, July 5, 1954; San Salvador, June 10, 1925, K. A. Salman.

Remarks: This is another of the species with prolonged tips to the elytra. The two South American species, *G. aeneipennis* Baly and *G. fascicularis* Baly, both have less pronounced and not so long tips at the apex of the elytra. The North American species *G. cryptica* Say has the tips more marked in the male and is of a reddish-brown color with scalelike pubescence and coarser punctures, especially on the pronotum. *Glyptoscelis cryptica* also has simple claws. Unlike these other species the tips of *G. chontalensis* are not divergent but united into one prolonged apex.

***Glyptoscelis guatemalensis*, new species**

FIGURE 32

Approximately 7.5 mm. in length, oblong oval, shining bronzy black, sometimes with a greenish lustre, antennae and legs deep reddish brown, prothorax rather finely punctate with a median

vertical bare line, elytra with a narrow prolongation, more marked in male, whole body covered with fine white hairs.

Head very lightly punctate over occiput and more densely but finely punctate on front, with fine, white, closely appressed hairs; eyes slightly emarginate at antennal sockets, labrum reddish brown. Antennae reddish brown, slender, extending below humeri. Prothorax not very convex with rounded sides, an acute tooth at basal and apical angles, and an impunctate median line, punctures fine and shallow, moderately dense, with fine white pubescence falling horizontally away from median bare line. Scutellum shining piceous with a few white hairs. Elytra not much wider than prothorax with humeral prominences, not depressed at all below scutellum but with a little swelling there; punctation fine, not dense, and with horizontal ridging between, particularly noticeable on sides below humeri; apex of elytra with a prolonged narrow tip, not divergent and not so well developed in female; pubescence fine, white, and not entirely concealing surface beneath; in one specimen pale brown hairs intermixed. Length 7.5 mm.; width 3.4 mm.

Type: Male, in British Museum (Natural History). One paratype in U.S. National Museum.

Type-locality: Guatemala, Baly collection.

Remarks: There is a third specimen in the British Museum with similar labels of "Guatemala" and "Baly collection" that may possibly not be this species. In this one, the prothorax is deep reddish brown and the elytra have an aeneous green lustre. It is unfortunately a female, and there is only the slightest trace of a prolonged tip to the elytra. *Glyptoscelis guatemalensis* is a smaller and more slender species than *G. chontalensis* Jacoby and the prolongation of the elytra not so developed, particularly in the female. There is a more pronounced tip to the aedeagus, which in *G. chontalensis* is smoothly rounded without an acute tip at all.

Key to South American Species of *Glyptoscelis*

- 1. From 11.5 to 14.5 mm. in length (Brazil, Argentina)**gigas** Jacoby
Smaller 2
- 2. Tips of elytra narrowly prolonged 3
Tips of elytra not prolonged 4
- 3. Aedeagus triangular at apex, pubescence on prothorax with vittate pattern**fascicularis** Baly
Aedeagus round at apex, pubescence on prothorax without vittate pattern**aeneipennis** Baly
- 4. Aedeagus with a long narrow tip 5
Aedeagus rounded at apex 6
- 5. Prothorax with a median bare area (Colombia)**dohrni** Jacoby
Prothorax without a median bare area (Chile)**gayi** Lefèvre

6. Prothorax reddish brown, elytra faintly aeneous (Paraguay).
paraguayensis Jacoby
 Prothorax piceous black 7
7. Prothorax approximately as wide as elytra and not very convex (Chaco and Formosa Provinces, Argentina) pinnigera Blake
 Prothorax more convex, with more apparent median bare line (Entre Rios Province, Argentina) monrosi Blake

Glyptoscelis dohrni Jacoby

FIGURE 38

Glyptoscelis dohrni Jacoby, 1900, Trans. Ent. Soc. London, p. 501.

About 6 mm. in length, oblong oval, shining, elytra with faint bronzy lustre, mostly lustrous black, antennae and legs reddish brown; prothorax moderately finely and not very densely punctate with a median bare line, elytra more coarsely but not much more densely punctate with white appressed pubescence that on prothorax is horizontally arranged, not so dense as to obscure surface on either prothorax or elytra.

Head shining, finely and sparsely punctate and lightly covered with white pubescence, lower front with a median impunctate line, labrum reddish brown, interocular space barely half width of head, eyes with only slight emargination at antennal sockets. Antennae short, extending below humeri, outer joints somewhat thickened, seventh joint long, pale reddish brown. Prothorax moderately convex, widest at base with only slightly curved sides, anterior angle curved forward below eyes; punctation moderately dense and not coarse, with a median bare line, a fine feathery pubescence arranged horizontally from median line, not entirely obscuring shining black surface. Scutellum black, with a few fine white hairs. Elytra not depressed about scutellum, tapering to apex, which is pinched in but not at all prolonged; intrahumeral depression faint, surface very shiny with a faint bronzy lustre and moderately coarsely and not densely punctate with a tendency to horizontal ridging; white pubescence not dense or obscuring surface. Undersurface with thick white pubescence, denser along sides, legs reddish brown. Length 6.2 mm.; width 3 mm.

Type: In British Museum (Natural History), with 3 paratypes.

Type-locality: Colombia, collected by Rehlke.

Other locality: COLOMBIA: Cartegena, Bolivar Prov., on chaparral, July 11, 1920, F. R. Mason.

Remarks: The smaller size and stouter build as well as lack of any prolongation at the apex of the elytra differentiate this from the other two Colombian species, *G. aeneipennis* Baly and *G. fascicularis* Baly. The aedeagus is unusual in shape with a tip that is narrowly

prolonged. Jacoby wrote that specimens were in his collection and also in the Stettin Museum.

Glyptoscelis aeneipennis Baly

FIGURE 36

Glyptoscelis aeneipennis Baly, 1865, Trans. Ent. Soc. London, ser. 3, vol. 2, p. 334.

From 7.5 to 8.5 mm. in length, elongate oblong oval, apex of elytra with a prolonged tip; elytra usually having a greenish lustre, head, prothorax, antennae and legs reddish brown, sometimes head and prothorax piceous; prothorax not very coarsely punctate with a median bare line and some bare round spots; elytra more coarsely punctate and horizontally ridged in places, postscutellar region not at all depressed, a little raised; pubescence on prothorax feathery and arranged horizontally from median line, on elytra not so thick as to cover surface, white interspersed with brownish hairs and scattered patches of thicker white hairs in four rows on each elytron.

Head with interocular space approximately half width of head, usually a median depressed line down occiput and front, which are finely and not densely punctate and thickly covered with fine white appressed pubescence; labrum usually yellowish or reddish brown. Antennae reddish brown, extending slightly below elytral humeri; apical joints not much widened, seventh joint longer than rest. Prothorax moderately convex with lateral sides nearly straight, broadest at base, basal margin sinuate over scutellum; disc shining, finely punctate, with bare median line and scattered small round bare spots, mostly near apex and base on either side of median line; reddish brown or piceous. Scutellum deep reddish brown or piceous with a few white hairs. Elytra with an intrahumeral sulcus and a somewhat raised postscutellar region, greatest width at humeri, gradually tapering after the middle to the apex, which is produced noticeably into two slightly divergent tips; surface shining, usually with a greenish lustre, more coarsely punctate than prothorax, punctures tending to be geminate striate with the intervals having finer punctures, some horizontal ridging; pubescence usually white with scattered brown hairs and a few denser patches of white distributed unevenly on each elytron in four lines. Body beneath covered with white, closely appressed pubescence, denser on sides; legs usually reddish brown. Length 7.5–8.5 mm.; width 3.5–3.8 mm.

Type: In British Museum (Natural History).

Type-locality: Venezuela, Trinidad.

Other localities: VENEZUELA: Santa Rita, Edo. Aragua, June 25, 1943, injuring *Gossipium hirsutum*, G.V. Berthier; Maracay, May 1935, A. Escalona Salas. COLOMBIA: Carare, 1939, H. Daniel; Pto. Berrie, Aug. 3, 1938, H. Dybas.

Remarks: The type of this species in the British Museum is a much rubbed specimen, but what is left of the feathery white pubescence on the prothorax is typical. On the elytra the pubescence is mostly white with numerous thicker patches, in rows. The prothorax and scutellum are reddish brown. The apex of the aedeagus is like that of many other species, being rounded with a tiny knob at tip. This species is the first of two described by Baly on the same page, the second one being *G. fascicularis*, whose habitat is given as Colombia. *Glyptoscelis fascicularis* was synonymized by Jacoby with *G. aeneipennis*. It is very difficult to separate the two by any external characters, but the aedeagi are entirely different. Baly gave the differences as being that *G. fascicularis* is somewhat larger with fuscous pubescence on the upper side of the body. The latter character, the fuscous pubescence, is better than the size, which is not very different in many specimens. *Glyptoscelis aeneipennis* has more uniformly white pubescence, especially noticeable on the prothorax. Often, however, the white elytral pubescence is interspersed with brownish hairs, but not quite to the extent of *G. fascicularis*.

***Glyptoscelis fascicularis* Baly**

FIGURE 35

Glyptoscelis fascicularis Baly, 1865, Trans. Ent. Soc. London, ser. 3d, vol. 2, p. 334.

Glyptoscelis aeneipennis Jacoby, 1900, Trans. Ent. Soc. London, p. 502.

From 7.5 to 10 mm. in length, elongate oblong oval, widest at humeri, elytra tapering and with a narrow apical prolongation; postscutellar area with a definite hump; elytra usually with greenish lustre, prothorax and scutellum usually and antennae and legs always reddish brown; usually brownish pubescence on prothorax arranged horizontally from median bare impunctate area, and usually heavier white pubescence on sides and on each side of middle, forming four white vittae; pubescence on elytra usually brownish with denser white patches in rows.

Head with interocular space half width of head, a median line down front, finely punctate, and with brownish pubescence. Antennae pale reddish brown, extending below humeri, not much widened in apical joints, seventh joint long. Prothorax moderately convex with slightly rounded lateral sides, widest at base, a median bare line and round bare spots on either side, punctation not coarse but dense, usually brownish pubescence horizontally arranged from median line, and with denser white hairs on either side and near lateral margin, forming four white vittae. Scutellum usually reddish brown with a few hairs. Elytra widest at humeri with a definite hump behind scutellum, tapering to apex, which is narrowly pro-

longed into two slightly divergent tips; pubescence not so dense as to hide greenish lustre of surface or the punctation, which is not very dense and has a tendency to be striate; some horizontal ridging, pubescence usually brownish with white patches of denser hairs arranged irregularly in four rows on each elytron. Body beneath covered, especially thickly on sides, with white pubescence. Length 7.3–10 mm.; width 3.4–4.7 mm.

Type: In British Museum (Natural History).

Type-locality: Colombia.

Other localities: TRINIDAD: St. Augustine, June 16, 1944, on *Cordia*, A. M. Adamson; Port of Spain, July 1907, O. W. Barrett; Trinidad, F. W. Urich, Augustus Busek; Caroni River, Oct. 12, 1918, Harold Morrison. GRENADA: June, A. Busek. VENEZUELA: Santa Rita, Edo. Aragua, June 25, 1943, on *Gossipium hirsutum*, G. V. Berthier; La Providencia, Maracay, Apr. 5, 1933, L. F. Martorell; Acarigua Portuguesa, on *Psidium* sp. COLOMBIA: Villavicencio, June 10, 1938, H. Dybas; Villanueva, July 9, 1938, H. Dybas.

Remarks: In general, this species has a browner appearance than *G. acneipennis* because of the pubescence, but otherwise it is difficult to distinguish by its external form. The pubescence on the prothorax tends to form four white vittae. In addition to the differences found in the pubescence there is a more decided hump behind the scutellum. In *G. acneipennis* this is not so developed. But the only certain way of distinguishing the two is by the shape of the apex of the aedeagus. In *G. fascicularis* it is triangular, and in *G. acneipennis* it is rounded. There is no definite difference in their distribution nor apparently in their food plant, as in one instance, both species were collected at the same time on cotton at Santa Rita, Venezuela.

Glyptoscelis monrosi Blake

FIGURE 33

Glyptoscelis monrosi Blake, 1952, Act. Zool. Lilloana Inst. "Miguel Lillo," vol. 10, pp. 163–5.

Between 7 and 7.5 mm. in length, oblong oval, shining piceous, prothorax rather finely punctate with a median impunctate line and several round impunctate areas, elytra more coarsely and rugosely punctate, pubescence long and white with denser white patches in four lines on each elytron; antennae and tibiae and tarsi reddish brown.

Head with interocular space a little more than half width of head; lower front without much evidence of separation from upper, densely and finely punctate, with a trace of median line and with fine, closely appressed white pubescence, labrum yellowish or reddish brown. Antennae reddish brown, except the dark basal joint, not extending

much below humeri, outer joints distinctly wider. Prothorax with rounded sides, widest at base, convex, densely and finely punctate with a bare impunctate median line and several small round impunctate areas; pubescence moderately long and thick, covering surface. Scutellum black, with a few white hairs. Elytra convex with a short intrahumeral sulcus and no depression about scutellum; shiny, piceous, densely punctate with horizontal ridges between punctures; pubescence moderately dense and with patches of long white hairs in four lines on each elytron. Body beneath with long white pubescence, tibiae and tarsi reddish brown. Length 7-7.5 mm.; width 3.2-3.8 mm.

Type: U.S. National Museum no. 65355.

Type-locality: Rosario del Tala, Entre Rios, Argentina, December 1941, F. Monros.

Other localities: ARGENTINA: Gualeguaychu, Entre Rios, December 1941, Haldo; Santa Elena, Entre Rios, Jan. 18, 1912, G. E. Bryant.

Remarks: This is a more convex and a more densely pubescent species with more white patches of hairs on the elytra than *G. pinnigera*. Its median prothoracic line is more plainly evident too. It comes from Entre Rios Province, which is quite a different environment from that of *G. pinnigera* from the Chaco region.

Glyptoscelis pinnigera Blake

FIGURE 34

Glyptoscelis pinnigera Blake, 1952, Act. Zool. Lilloana Ins. "Miguel Lillo," vol. 10, pp. 165-6.

From 6 to 7 mm. in length, oblong oval, shining black, antennae and sometimes tibiae and tarsi reddish brown, prothorax about one-third wider than long, nearly as wide as elytra, lightly pubescent and finely punctate with remnants of a median bare impunctate line and several small round impunctate areas on either side; elytra more coarsely punctate.

Head with interocular space slightly more than half width of head, lower front not very distinctly separated from upper, finely punctate with usually a median bare impunctate line down front, pubescence brownish and white. Antennae extending slightly below humeri, reddish brown with the basal joint darker, seventh joint long and apical joints wider. Prothorax nearly as wide as elytra and not very convex (for the genus as a whole); rather finely and densely punctate with numerous small round bare spots, and often part of a bare median line; a fine feathery brown and white pubescence arranged horizontally from the middle. Scutellum with a few hairs. Elytra with a short intrahumeral sulcus, no depression or elevation about scutellum, punctation coarser than that of prothorax with horizontal

ridging between and, on either side of suture, in apical half, often a bare line parallel to suture, sometimes interrupted with patches of denser white pubescence; the brown and white pubescence not so dense as to hide surface. Body beneath with denser white pubescence, base of femora, tibiae and tarsi usually reddish brown. Length 5.8–7.2 mm.; width 3–3.6 mm.

Type: U.S. National Museum no. 65356.

Type-locality: Resistencia, Prov. Chaco, Argentina, F. Monrós.

Other localities: ARGENTINA: Mision Laishi, Formosa Prov., September 1950, Willink and Monrós; Santiago del Estero, Jan. 18, 1912.

Remarks: The wide and not very convex prothorax is the most distinctive character of this species. The three species *G. paraguayensis* Jacoby, *G. pinnigera*, and *G. monrosi* Blake are all very similar, but *G. pinnigera* differs from the other two in its broad, not very convex prothorax. It comes from the Chaco region. Beetles were observed by Willink and Monrós feeding on *Prosopis*. The species described by Schaeffer from Brownsville, Tex., was named by him *G. prosopis*, presumably because it too was taken on mesquite.

***Glyptoscelis paraguayensis* Jacoby**

FIGURE 31

Glyptoscelis paraguayensis Jacoby, 1897, Entomologist, vol. 30, p. 260.

Glyptoscelis paraguensis, Clavareau, 1914, Coleopterorum catalogus, par. 59, p. 130.

About 7 mm. in length, elytra tapering to apex, widest at humeri, prothorax reddish brown, elytra faintly aeneous green; antennae and legs reddish brown; pronotum finely punctate with a median impunctate line; elytra more coarsely and distantly punctate; pubescence with brown and white hairs intermingled.

Head closely covered with brown and white hairs. Antennae extending below humeri, reddish brown. Prothorax with rounded sides, densely and strongly punctate with a median vertical impunctate line; reddish brown with brown and white hairs horizontally arranged from the median line, and obscuring punctation. Elytra widest at humeri and tapering to apex, with a pinched-in depression before the tip and a considerable thickness of white hairs producing a small prolongation at apex; pubescence on elytra of mingled brown and white hairs resulting in a mottled wavy effect; surface beneath with an aeneous green lustre; more coarsely punctate than prothorax and with horizontal ridging. Body beneath reddish brown, densely covered with white hairs. Legs reddish brown. Length 7 mm.

Type: In British Museum (Natural History).

Type-locality: Paraguay.

Remarks: The coloring of this species, of which only the type has been seen, differs from the coloring of *G. monrosi* Blake and *G. pinnigera* Blake in that the prothorax is deep reddish brown and the elytra have a distinctly aeneous-green lustre. In addition, the shape of the elytra is different in being more tapering, with a suggestion of a prolongation at the tip. The drawing of the type at the British Museum unfortunately was made on a smaller scale than for the rest of the species. The beetle, measuring about 7 mm., is comparable in size with *G. monrosi* and *G. pinnigera*.

Glyptoscelis gayi Lefèvre

FIGURE 39

Glyptoscelis gayi Lefèvre, 1891, Ann. Soc. Ent. Belgique, vol. 35, p. 270.

Between 8 and 9 mm. in length, oblong oval, shining black, prothorax densely and deeply punctate, without median bare line, elytra with very strong horizontal ridges, white pubescence on upper surface not dense or obscuring surface.

Head with interocular space more than half width of head, head coarsely and densely punctate, the suture about lower front separating it from upper front very indistinct, a fine white pubescence, labrum reddish brown. Prothorax strongly convex with lateral sides only slightly curved, widest at base, slightly wider than long, surface densely and deeply punctate with coarse round punctures over all, no median bare line, the white pubescence fine and not obscuring surface. Scutellum black. Elytra with deep intrahumeral sulcus, neither depressed nor elevated behind scutellum; surface very rugose with strong horizontal ridgings between rows of punctures, along side near apex a more or less distinct costa, which at apex unites with a vague subsutural apical costa in a small knobby prominence; pubescence fine, white, not obscuring surface. Body beneath with much heavier white pubescence, legs reddish brown. Length 8–9.5 mm.; width 3.5–4 mm.

Type: In Museum of Natural History, Paris.

Type-locality: "Chili (Santa Rosa)."

Other localities: CHILE: Serena, Coquimbo, Illapel.

Remarks: The drawing of this species was made from a specimen from the Monrós collection bearing the label "*Glyptoscelis Gayi* Ed. Lef. Auct. det. 1894." The locality is simply "Chili Gay." It is undoubtedly authentically determined. There are four specimens in the Frey Museum. These are the only ones examined by the writer. The species is distinctive because of the strong horizontal ridgings on the elytra, which are stronger than in any other species of the genus. The aedeagus is unusual in its long narrow tip. The punctuation of the prothorax is deep and close.

Glyptoscelis gigas Jacoby

FIGURE 37

Glyptoscelis gigas Jacoby, 1897, Entomologist, vol. 30, p. 262.

Between 11.5 and 14.5 mm. in length, elongate oblong oval, not very shiny, with white or yellowish, closely appressed, scalelike pubescence, deep reddish brown to piceous, with dark-brown to piceous antennae and legs, densely and not very coarsely punctate, punctures with horizontal ridging in basal part of elytra; pubescence arranged in three vitta lines of denser scales on sides and middle of both pronotum and elytra.

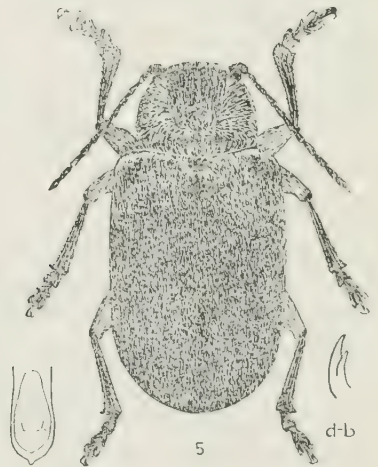
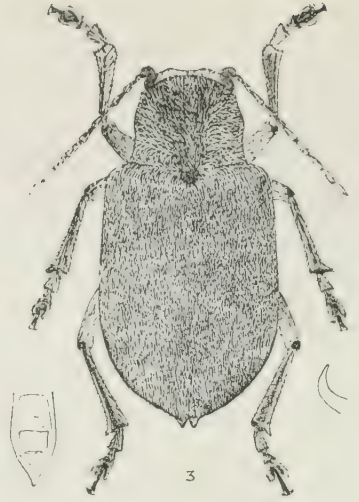
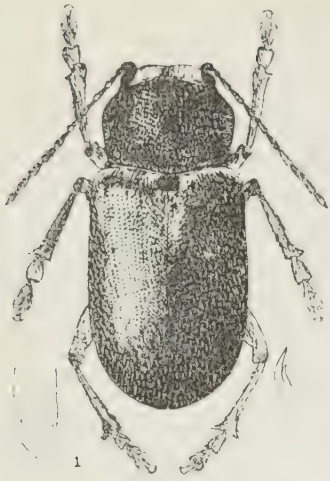
Head with eyes emarginate at antennal sockets, a median line down front, not very densely or coarsely punctate and with closely appressed, white, scalelike pubescence. Antennae dark brown, with fine white hairs, not extending to middle of elytra, outer joints slightly thicker, seventh joint long. Prothorax with slightly curved sides, convex, and with a well-marked depression in middle of base, rather densely and not very coarsely punctate, not very shiny, with three more densely pubescent areas forming two lateral and a median pale vitta. Scutellum broader than long, finely punctate, and with scales. Elytra very long, tapering gradually from humeri, which are the widest part of elytra, to apex, which is sharp but not produced as in *G. aeneipennis* Baly; surface transversely wrinkled and with not very coarse or dense punctures becoming finer and sparser in apical half and on sides, pubescence in form of lateral and sutural three white vittae, with sparser white scales scattered between; in one specimen these vittae widen toward apex to cover entire apex, this specimen also bright reddish brown and larger than the others (14.5 mm.). Body beneath covered with pale scales, in the reddish-brown one the entire lower (apical) half pale with pubescence, not so dense in darker specimens. Claws with very short inner tooth near base. Length 11.5–14.5 mm.; width 5–5.8 mm.

Type: In "Oxford Museum."

Type-locality: Brazil, "without particular locality, obtained by Myers."

Other localities: ARGENTINA: La Rioja; El Borbollon, Mar. 13, 1944, F. Monrós; Rio Salado, Santiago del Estero, Wagner.

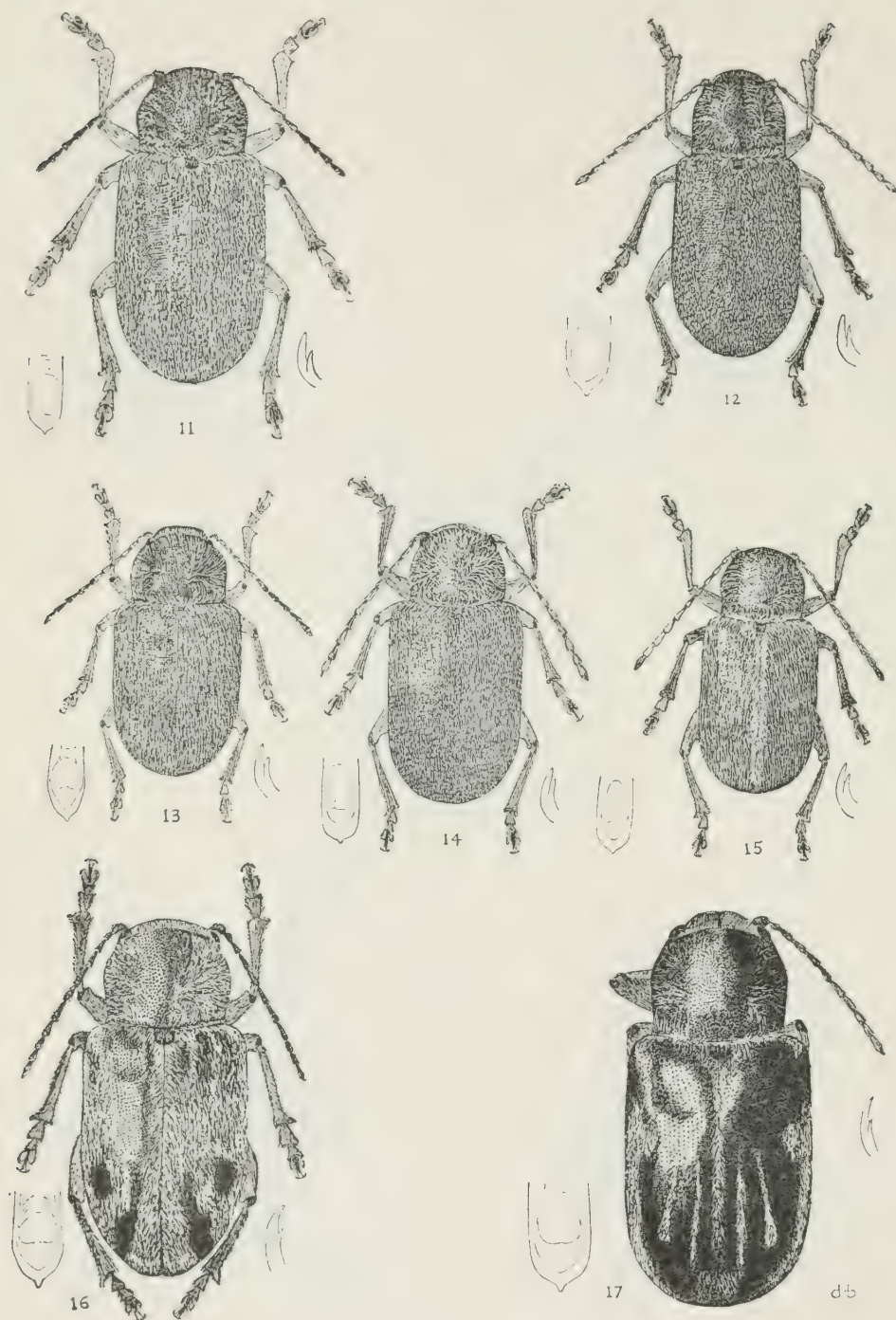
Remarks: Except the type, which I have not examined, only three specimens are known to the writer. These three are all from the Monrós collection, and all from Argentina. Two of them are dark brown and much rubbed, so that there are not many scales left, the third specimen, bright reddish brown and covered with pale yellowish scales, is larger. Whether all three are one species I cannot determine because of lack of material, but the one drawn, which is brownish piceous with white pubescence, corresponds with Jacoby's description. Jacoby wrote that this is the largest species not only of the genus but of the whole group of Myochroini. A new genus possibly may be erected for it at some future time.



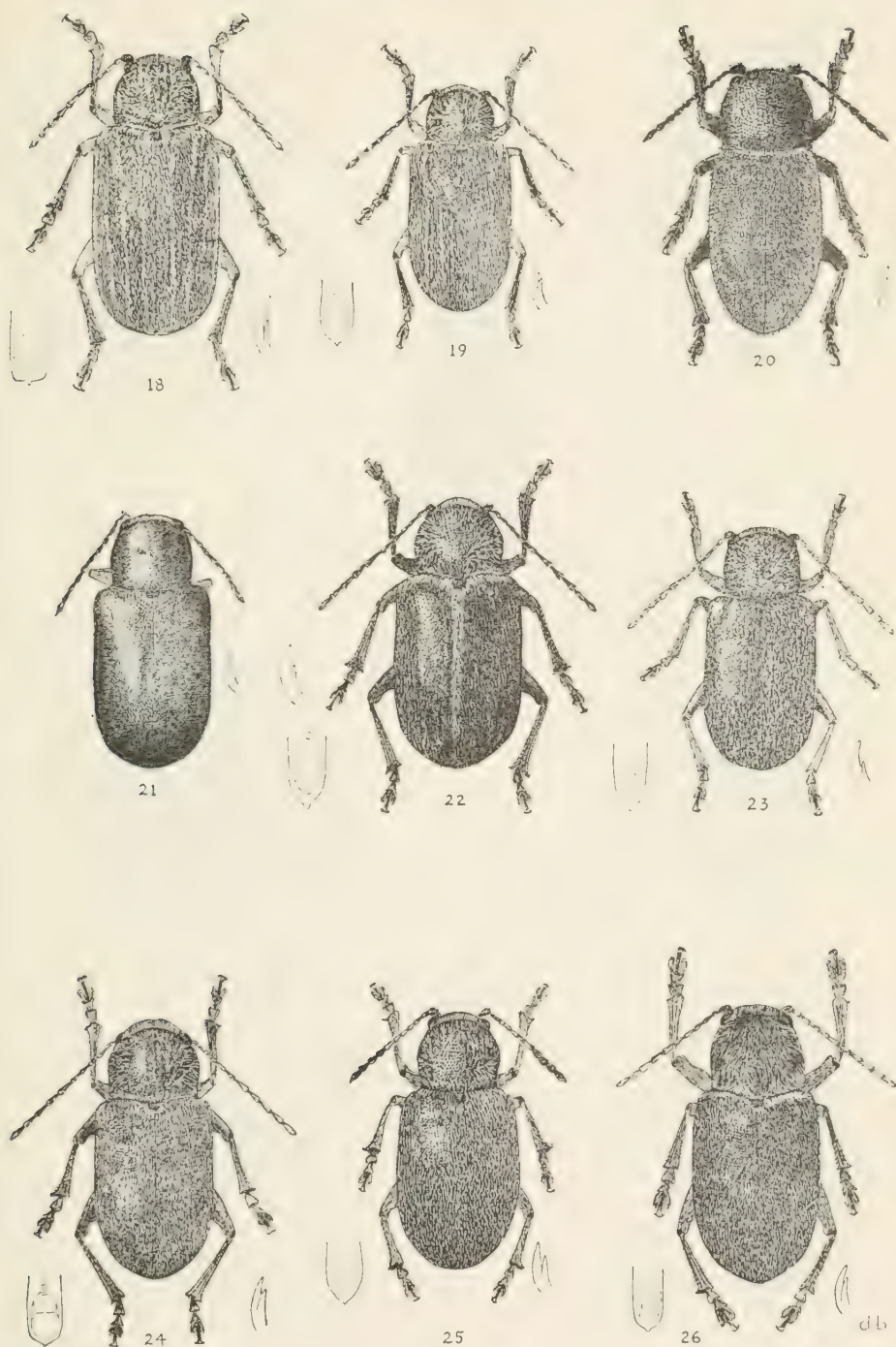
FIGURES 1-5.—1, *Glyptoscelis pubescens* (Fabricius); 2, *G. barbata* (Say); 3, *G. cryptica* (Say); 4, *G. alternata* Crotch; 5, *G. albicans* Baly.



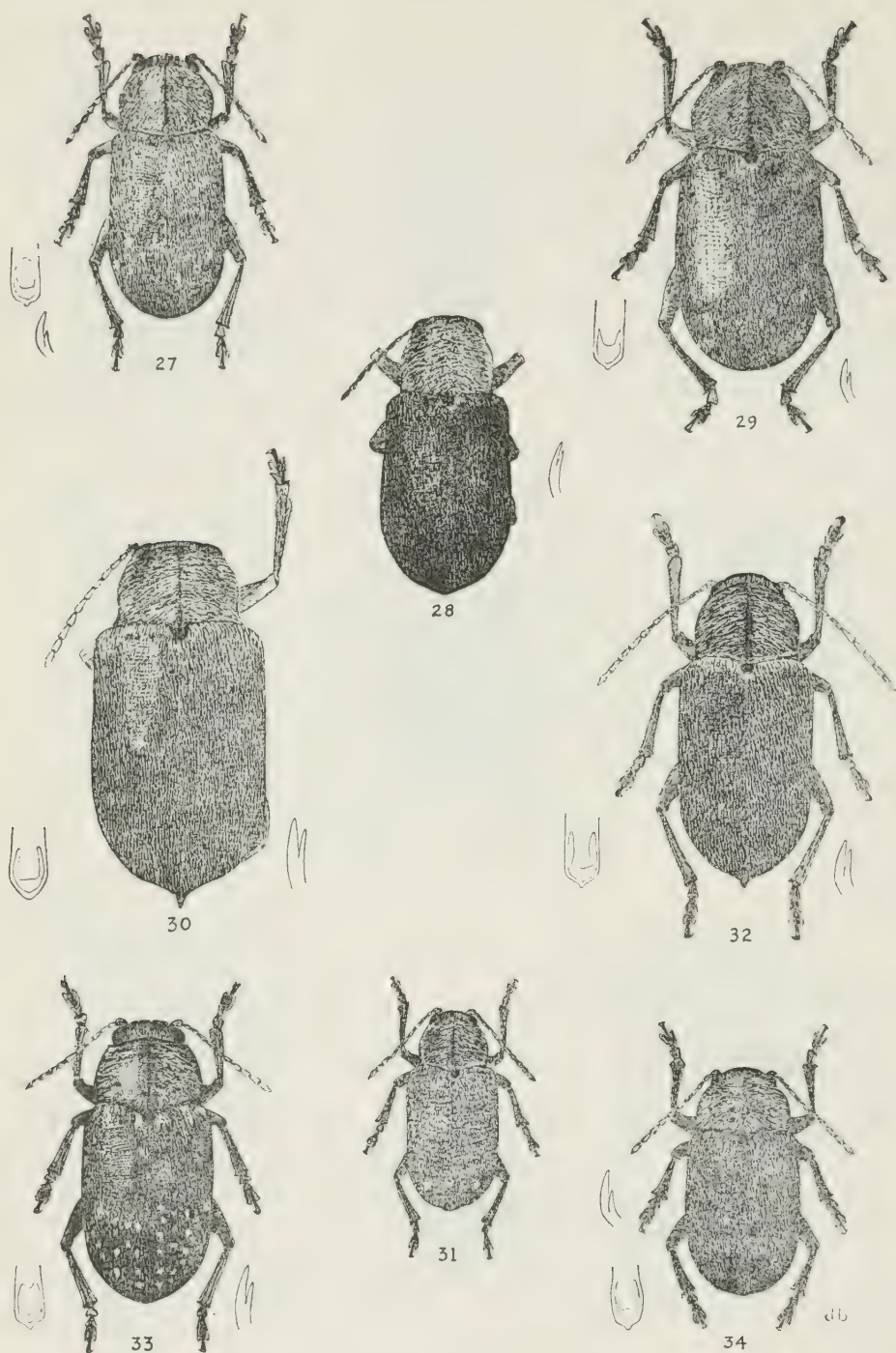
FIGURES 6-10.—6, *Glyptoscelis squamulata* Crotch; 7, *G. albida diabola* Krauss; 8, *G. albida* LeConte (type); 9, *G. vandykei* Krauss, new status; 10, *G. albida yosemitae* Krauss.



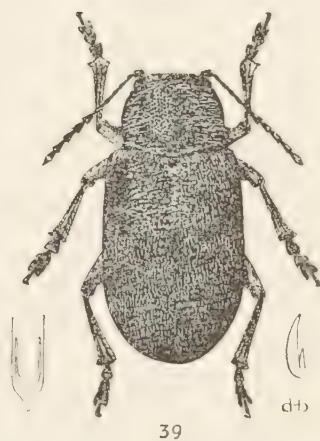
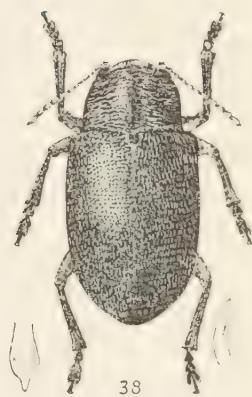
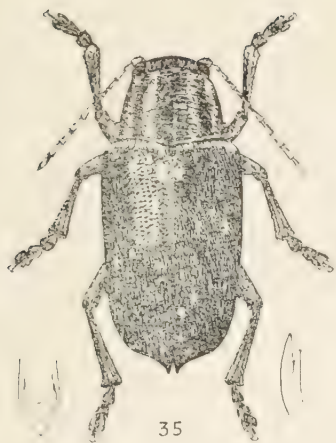
FIGURES 11-17.—11, *Glyptoscelis idahoensis*, new species; 12, *G. peperi*, new species; 13, *G. sequoiae* Blaisdell; 14, *G. juniperi*, new species; 15, *G. juniperi xanthocoma*, new subspecies; 16, *G. aridis*, Van Dyke, new status; 17, *G. illustris* Crotch (type).



FIGURES 18–26.—18, *Glyptoscelis artemisiae*, new species; 19, *G. paula*, new species; 20, *G. cylindrica*, new species; 21, *G. longior* LeConte (type); 22, *G. septentrionalis*, new species; 23, *G. longior* LeConte; 24, *G. coloradoensis*, new species; 25, *G. parvula* Blaisdell; 26, *G. prosopis* Schaeffer.



FIGURES 27-34.—27, *Glyptoscelis sonorensis*, new species; 28, *G. mexicana* Jacoby (cotype); 29, *G. cahitae*, new species; 30, *G. chontalensis* Jacoby (cotype); 31, *G. paraguayensis* Jacoby; 32, *G. guatemalensis*, new species; 33, *G. monroisi* Blake; 34, *G. pinnigera* Blake.



FIGURES 35-39.—35, *Glyptoscelis fascicularis* Baly; 36, *G. aeneipennis* Baly; 37, *G. gigas* Jacoby; 38, *G. dohrni* Jacoby; 39, *G. gayi* Lefèvre.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3605

Observations On the Pelagic Distribution of Seabirds In the Western Indian Ocean

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In 1952, regarding our knowledge of seabirds, the Indian Ocean was considered to be the least-explored part of the world ocean (Murphy, 1952). The validity of this statement was dramatized soon thereafter by the discovery of two new petrels, *Bulweria fallax* (Jouanin, 1955) and *Pterodroma barau* (Jouanin, 1963), and an Indian Ocean breeding colony of a third petrel, *Pterodroma arminjoniana* (Murphy and Penoyer, 1952). Still, the need for information on the pelagic distribution and behavior of seabirds in the Indian Ocean remains (Bourne, 1963), for, although summaries of the scattered accounts are available (Bourne, 1960, 1963; Jouanin, 1957; Watson, Zusi, and Storer, 1963), the information on which they are based comes primarily from well-travelled commercial routes. By contrast, the rest of that ocean has received scant attention.

The International Indian Ocean Expedition (IIOE), a multi-nation endeavor coordinated and sponsored by UNESCO, has been

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making possible the accumulation of seabird observations by scientific personnel aboard oceanographic research vessels that are systematically transecting the entire Indian Ocean. Some of the resulting information has already been published (Bailey, 1964, 1965, 1966; Pocklington, 1965; Pocklington and Risebrough, 1964; Rand, 1962, 1963). The present report is based on observations and collections made by the author during IIOE cruise 5 of the R/V *Anton Bruun* from January through April 1964 and also during a voyage of the commercial vessel s.s. *Kampala* in May 1964.

The cruise tracks of these two voyages are outlined in figure 1 and the details of the itineraries are included in table 1. Cruise 5 of the *Anton Bruun* originated and terminated in Bombay, India, on Jan. 26 and May 4, 1964, respectively and consisted of a direct transit across the Arabian Sea from Bombay to the Gulf of Aden followed by a north-south transect of the western Indian Ocean on longitude 55° E and a south-north transect on longitude 75° E. A direct run from Mauritius to 40° S, 75° E, connected the two transects. The passage from Bombay to the Seychelles from May 17 to June 2, 1964, was a scheduled run of the *Kampala* (British-India Lines) and included stops at Karachi, Mombasa, and Zanzibar.

At each station on the *Anton Bruun*'s itinerary, I maintained a 2-3-hour standardized watch for seabirds from the bridge of the ship. During this period the ship was essentially stationary. In the evening, while in transit to the next day's station at an average speed of 10-12 knots, I counted seabirds again for an hour before dusk. Records also were kept of all birds sighted between watch periods; when I was not on deck, I was alerted to the presence of seabirds by the officers on watch.

The main difference influencing the observations made from the *Kampala* was the continuous movement of the ship (15 knots) and the fact that I could only watch from one side of the ship at a time, narrowing the radius of observation from 360° to slightly less than 180°.

Some seabirds were collected from a small rubber "Zodiac" boat in subantarctic waters and during our brief visits to the Seychelles, Mauritius, Amsterdam, and St. Paul Islands. Although the latter two islands will be included in this report, only those birds seen at sea in the vicinity of the Seychelles and Mascarene Islands are discussed here, as studies on these islands were continued from June to November 1964 and will be published elsewhere.

In the course of this work I have kept detailed notes and descriptions of all unfamiliar seabirds and have found the following references especially useful for identification: "Birds of the Ocean" (Alexander, 1954), "The Petrels of the Indian Ocean" (Bourne, 1960), "A Preliminary Field Guide to Birds of the Indian Ocean" (Watson, Zusi, and

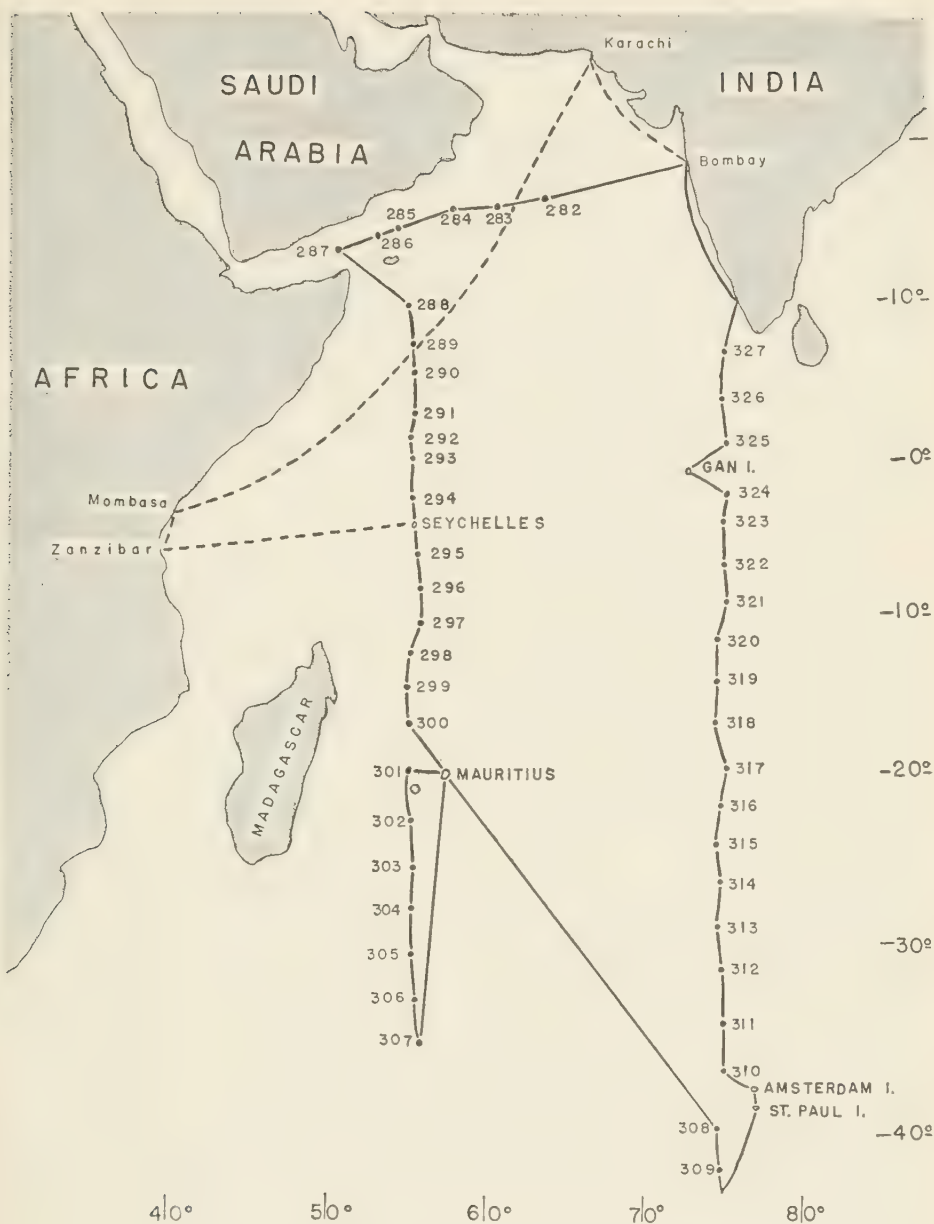


FIGURE 1.—Cruise tracks and station positions.

— R/V *Anton Bruun*: Jan. 26 to May 4, 1964- - - T.S.S. *Kampala*: May 17 to June 2, 1964

Storer, 1963). The nomenclature used follows that of Peters (1931, 1934) except in a few cases wherein recent revisions or descriptions were applicable. All specimens have been cataloged in the collections of the U.S. National Museum in Washington, D.C.

This work was supported by a National Science Foundation grant to Dr. I. E. Wallen of the Smithsonian Institution in Washington as part of the U.S. Program in Biology, International Indian Ocean Expedition. Drs. Philip S. Humphrey, Robert W. Storer, and George E. Watson offered numerous helpful suggestions and encouragement throughout the course of my Indian Ocean field activities and in the preparation of this report. I am indebted also to all my companions aboard the *Anton Bruun* for their assistance and independent contributions and to Claudia L. McPeck, who handled the countless administrative and other details connected with my participation in this expedition. Roger S. Bailey provided stimulating discussion of the problems of seabird distribution that are the concern of this paper and made available many of his unpublished observations and thoughts. John P. Hubbard and Guy Musser helped with the illustrations. Finally, I am most grateful for the assistance rendered by my wife Frances in the typing of the final draft of this manuscript.

SEABIRD ABUNDANCE.—Included in table 1 are the numbers of seabirds (grouped by order) observed during the standardized watch periods and a calculated figure for the number of birds seen per hour during each watch. The relationship of the latter figure to the actual density of seabirds in a given area is biased by many variables including the movement of the ship, movement of the birds, conditions for observation, and perhaps time of day. The first of these may be particularly important (compare Bailey, 1966, p. 261) since seabirds rarely are distributed uniformly at sea but instead congregate at and move with localized sources of food. Hence, any substantial movement of the ship should increase the likelihood of encountering non-randomly distributed seabirds. If this is true, the counts I made during the morning watches on station are not directly comparable to evening watches or others made when the ship was cruising at normal speeds. An additional complication is the possibility that the greater duration of the morning watches increased the chances of seeing small groups of moving birds and partially compensated for the lack of movement of the ship. Despite these and other problems inherent in the quantification of at-sea observations, at least five regions were found where seabirds were more common than in the intervening areas. These were: (1) the western Arabian Sea and south along the coast of Somalia; (2) the Seychelles Islands and surrounding seas; (3) the waters near the Mascarene Islands; (4) subantarctic waters below 33° S; (5) the seas east of the Maldive Islands and north to the Indian coast. A sixth region near the equator also might be distinguished though the increase there was less pronounced than in the other areas. In these regions the number of seabirds seen per hour was definitely greater than 2-3, usually 10-30, and on some occa-

sions reached 100–200.² In the intervening seas an average of one bird or less was seen per hour.

REGIONAL SUMMARIES.—In the Arabian Sea, Jouanin's petrel (*Bulweria fallax*) and the red-billed tropicbird (*Phaëthon aethereus*) were the two species most commonly encountered in January although, close to the Gulf of Aden and Socotra, Audubon's shearwaters (*Puffinus lherminieri*) were quite common and the lesser black-backed gull (*Larus fuscus*), Aden gull (*Larus hemprichii*), masked booby (*Sula dactylatra*) and brown booby (*Sula leucogaster*) also were found. The primary difference within this general region in the following May was the appearance of several storm petrels, i.e., Wilson's petrel (*Oceanites oceanicus*), frigate petrel (*Pelagodroma marina*), and either the white-bellied storm petrel (*Fregetta grallaria*) or the black-bellied storm petrel (*Fregetta tropica*). Storm petrels also were seen at this time south along the African coast to Mombasa and east to the Seychelles Islands (see table 4).

Most of the breeding seabirds of the Seychelles Islands forage in large mixed flocks in the relatively shallow waters around these islands. Few species, however, except the sooty tern (*Sterna fuscata*) and the wedge-tailed shearwater (*Puffinus pacificus*), stray into the surrounding open seas with any regularity. Although flocks of up to several hundred sooty terns were seen near the Seychelles and east to the African coast in May and June, no sooty terns were seen in this region in January and February.

In the equatorial regions two all-dark storm petrels of uncertain identification (possibly *Oceanodroma monorhis* and *O. matsudairae*; see "Species Accounts") were encountered, as well as a tern, apparently the fairy tern (*Gygis alba*).

The numbers of seabirds found in the waters near the Mascarene Islands seemed impressive to me after having passed through the relatively barren region south of the Seychelles Islands. Flocks of sooty terns and wedge-tailed shearwaters, as well as scattered white-tailed tropicbirds (*Phaëthon lepturus*), appeared within 50 miles of Mauritius. A few common noddies (*Anous stolidus*) also were seen. Further to the southwest, Barau's petrel (*Pterodroma barau*) from Reunion was a common pelagic species, occurring with tropicbirds (*P. lepturus*) and Audubon's shearwaters (*Puffinus lherminieri*).

Below 34° S we encountered the albatrosses and petrels, characteristic of the cool water oceans of the southern hemisphere. The wandering albatross (*Diomedea exulans*), white-chinned petrel (*Procellaria aequinoctialis*), soft-plumaged petrel (*Pterodroma mollis*), and

² The increase near the Maldives was only subjectively apparent, as standardized watches permitting computations of birds seen per hour were not made in this region.

prions (*Pachyptila*) were the most abundant and conspicuous species while others such as the sooty albatross (*Phoebastria fusca*), shy albatross (*Diomedea cauta*), black-browed albatross (*Diomedea melanophris*), yellow-nosed albatross (*Diomedea chlororhynchos*), and great-winged petrel (*Pterodroma macroptera*) were seen regularly but in smaller numbers. Scattered individuals of only six other species were seen at sea in this region: Schlegel's petrel (*Pterodroma incerta*), giant petrel (*Macronectes giganteus*), pediunkler (*Adamastor cinereus*), sooty shearwater (*Puffinus griseus*), Wilson's petrel (*Oceanites oceanicus*), and white-bellied storm petrel (*Fregetta grallaria*).

St. Paul and Amsterdam Islands were once very important seabird breeding stations (Jouanin, 1953; Murphy and Irving, 1951). During cruise 5 of the *Anton Bruun*, we visited each of these islands briefly, St. Paul for a few hours in the late afternoon of Apr. 7 and Amsterdam Island the following day. Seabirds were numerous in the waters around both of these islands and included most of the common petrel and albatross species seen elsewhere at sea in this region; however, sooty albatrosses and white-chinned petrels were especially numerous near Amsterdam Island. Flocks of Antarctic terns (*Sterna vittata*) were feeding near both islands and, within one mile of St. Paul, we also found feeding flocks of the little shearwater (*Puffinus assimilis*). Aside from Rockhopper penguins (*Eudyptes crestatus*), we could find no seabirds on St. Paul Island itself, though a number of "petrel nests" were located in small crevices and under rocky overhangs. Although the island was infested with both rats and hares, the absence of seabirds may be attributed to the fact that most species would have finished breeding and left the island by this date. We therefore spent little time on Amsterdam Island but instead confined our collecting efforts to the waters just offshore.

On the 75° E transect few seabirds were seen north of 31° S until we reached the latitudes of the Chagos and Maldive Islands. Here we found dark shearwaters, apparently the pale-footed shearwater (*Puffinus carneipes*), and scattered flocks of sooty terns. Occasional tropicbirds (*P. lepturus*) also were seen.

Several species of seabirds known to breed on the Seychelles or Mascarene Islands were not observed in the course of the two voyages. These include the Trinidad petrel (*Pterodroma arminjoniana*), red-tailed tropicbird (*Phaëthon rubricauda*), greater frigate-bird (*Fregata minor*), red-footed booby (*Sula sula*), lesser noddy (*Anous tenuirostris*), and roseate tern (*Sterna dougalli*). All of these species were encountered during subsequent field work on these islands and will be included in other reports.

OCEANOGRAPHIC DATA.—Concurrent with my seabird observations, standard oceanographic measurements (temperature profiles, nutri-

ents, plankton abundance, and primary productivity) were being taken by other members of the *Anton Bruun's* scientific party. These data and the methods used in their determination are presented in detail in the "Final cruise report, *Anton Bruun* cruise #5" (Woods Hole Oceanographic Institution, March 1965), and will be summarized only briefly here. The values obtained for surface salinity (36.0–36.35‰), nutrient concentrations (PO_4 , .46–.49 $\mu\text{g A/l.}$; $\text{NO}^2\text{-N}$, .35–.60 $\mu\text{g A/l.}$), and primary productivity (18–44 $\mu\text{g C/l./d.}$)³ in the western Arabian Sea near the Gulf of Aden and Socotra (sta. 282–287) were consistently higher than most other locations visited. Although nutrient concentrations at a few of our southernmost stations (308–310) were comparable to or higher than Arabian Sea values, primary productivity levels were much lower (6–7 $\mu\text{g C/l./d.}$). Unfortunately, the results of analyses of plankton samples are not yet available. Surface water temperatures in the western Arabian Sea were several degrees lower than in the seas immediately to the south. This decrease in temperature and concomitant increase in the nutrient concentrations and productivity are indicative of strong local upwelling which is known to occur in that region and which is believed to be the major determinant of the composition and density of the seabird community there (Bourne, 1963; Bailey, 1966). Between the Arabian Sea and the Mascarene Islands on the 55° E transect, surface temperatures ranged from 26° to 29.2° C. At comparable latitudes on the 75° E transect they ranged from 27° to 30.1° C. A progressive decrease in temperature was noted south of the Mascarenes, but the drop (from 19° to 15° C) was especially pronounced from 35° to 40° S, the region of the subtropical convergence. It was also in this region that the numbers of seabirds increased markedly.

Species Accounts

Eudyptes crestatus

Rockhopper Penguin

Common at St. Paul Island on Apr. 7, where they were breeding in colonies on the steep grassy slopes though they were not nearly as abundant as Jeannel found them on these same slopes in February 1939 (Jeannel, 1941, pl. x). Many full-size young, which had lost most of the down tips on their juvenal feathers, were present, but no small young or eggs were found. The soft part colors recorded from five specimens were as follows: irides orange; bill dull orange; feet dark grey below, white above. Weights ranged from 1915 to 2475 grams (mean 2205 grams). The measurements (in mm)⁴ of

³ Average of combined values to depths of 25 percent incident light.

⁴ Made by George E. Watson, Division of Birds, U.S. National Museum, Washington, D.C.

two female specimens are as follows: wing 158,162; tail molting; crest 70, 72; culmen 46.5; bill from gape 56, 57; width of bill 13.5, 14; depth of maxilla 11; foot from heel 105, 110; middle toe and claw 70, 75.

Diomedea exulans

Wandering Albatross

One of the most common and conspicuous species in subantarctic waters below 33°52' S on Mar. 8-9 and Apr. 3-10, 1964, its numbers reaching a maximum (25) at our southernmost station (see table 2).

Six specimens were taken, two at sea at 40°04' S on Apr. 4 and four just off the coast of Amsterdam Island three days later. The weights of these specimens ranged from 14 to over 20 pounds. The soft part colors, including those of a brown-bodied immature were as follows: feet bluish grey to bluish white; irides brown; orbital ring light blue; bill flesh color. The gonads of these specimens were not enlarged.

On several occasions I observed a pair of birds that were sitting on the water engage in a ceremony in which one bird with its wings raised slightly over its back was fed regurgitated morsels by the other. The ceremony terminated when the receiving partner spread its wings fully, stretched its neck, pointing its bill upward, and uttered a high-pitched squealing note. It then relaxed its position. On several other occasions two birds nibbled simultaneously at the end of each other's bill without the exchange of any food or use of vocalizations. Murphy (1936, p. 558) describes similar courtship-like activities being engaged in at sea often by large groups of albatrosses.

Diomedea melanophris

Black-browed Albatross

We observed this small mollymauk only occasionally in subantarctic waters, primarily below 40° S on Apr. 4-6 (see table 2). A single individual was present at 36°58' S on Apr. 9.

Diomedea cauta

Shy or White-capped Albatross

Only occasional individuals were noted in subantarctic waters south of 36°58' S on Apr. 3-9 (see table 2).

Diomedea chlororhynchos

Yellow-nosed Albatross

We observed this mollymauk only occasionally between latitudes 34° S and 40° S on Apr. 3-10 (see table 2).

Two specimens collected off the coast of Amsterdam Island on Apr. 8 had the following soft part colors: bill black with yellow culminocorn becoming reddish toward the tip; irides brown; feet pink. They weighed 2370 grams (male) and 2395 grams (female) and both had small gonads. The female specimen, prepared as a study skin,

measured (in mm): wing 436; tail 191; culmen 114; tarsus 75; middle toe 109. The stomach of this specimen contained the remains of a fish and a sponge.

Phoebetria fusca

Sooty Albatross

Common in subantarctic waters below 34°32' S on Apr. 3-10, being most abundant near Amsterdam and St. Paul Islands on Apr. 7-8 (see table 2). Many buff-headed immatures were seen.

Twelve specimens were obtained, five at sea at 40°04' S, 75°00' E, on Apr. 4 and seven off the coast of Amsterdam Island on Apr. 8. The soft part colors of these specimens were recorded as follows: irides brown; feet flesh-color; bill black with yellowish stripe (dull white in immatures) on lower mandible. The weights (in grams) of seven specimens were as follows: 3 males 2600, 2650, 2545; 3 females 2930, 2390, 2370; immature (sex unknown) 2440. The gonads of adults were slightly enlarged, ovaries averaging 19 x 9 mm, testes 11 x 6 mm. Three skinned specimens, two adult males and an immature, measured (in mm): wing 496, 496, 483; tail 243, 266, 245; culmen 116, 113, 106; tarsus 87, 84, 82. Of seven stomachs examined, three contained fish remains, two contained large cephalopod beaks, one contained 13 cephalopod beaks, several large shrimp, and the remains of a fish, and one stomach was empty.

Phoebetria palpebrata

Light-mantled Sooty Albatross

One dark albatross with a light back seen at 43°31' S, 75°27' E, on Apr. 6 may have been this species.

Macronectes giganteus

Giant Petrel

Only two individuals, both dark phase, were seen, one at 42°23' S, 74°56' E, on Apr. 5 and the other just off the coast of Amsterdam Island on Apr. 8.

Daption capense

Cape Pigeon

I saw only one Cape pigeon briefly at 34°53' S, 69°37' E, on Apr. 2.

Pachyptila species

Prion

Prions, of undetermined species, were fairly common in the waters near St. Paul Island on Apr. 7 and south to 43°31' S on Apr. 4 to 7 (see table 3).

A single *Pachyptila desolata* came aboard the *Anton Bruun* on Apr. 8 when we were about 20 miles west of Amsterdam Island. It was a female with a small ovary and weighed 121.6 grams. The bill and feet were light blue, the irides brown. It measured as follows (in mm): wing 187; tail 96; culmen 26; width bill at base 13; tarsus 34; middle toe 34. The stomach contained several small white pebbles, very likely floating pumice.

Adamastor cinereus

Pediunkner

We saw only two, possibly three, individuals in subantarctic waters (see table 3).

Procellaria aequinoctialis

White-chinned Petrel

White-chinned petrels were common south of the subtropical convergence where they frequently followed our ship. Our northernmost record was of a single individual at 30°50' S, 55°09' E, on Mar. 7. Maximum numbers were encountered at 40°04' S, 75°00' E, on Apr. 4 and off the coast of Amsterdam Island on Apr. 8 (see table 3).

Twelve specimens were obtained, primarily off the coast of Amsterdam Island. The soft part colors noted were: feet black; irides brown; bill light grey green with black markings. The ovaries of ten females varied in size from 7 x 4 to 15 x 8 mm; testes of two males measured 7 x 5 and 8 x 5 mm. Of nine stomachs examined, three contained cephalopods; two contained fish; two contained both fish and cephalopods; one contained pieces of fish and bologna, the latter presumably from discarded galley refuse; and one was empty.

Although I never saw this species hover like a kestrel (Watson, Zusi, and Storer, 1963), it often stops short in midair and flutters to the surface of the water. Then, preceding diving, the petrel submerges its head as if looking about under water. When it finally dives, the wings are held partially outstretched and may, therefore, be used for underwater propulsion.

Puffinus carneipes

Pale-footed Shearwater

This dark shearwater can usually be distinguished by its large size, pale bill, and, from *P. pacificus*, by its short rounded tail. At a distance its large size and heavy flight are diagnostic. Many of the shearwaters seen near the Maldive Islands and west coast of India in late April (see table 4) were identified as this species as were four shearwaters seen on May 21 in the Arabian Sea. At least one of the birds seen near the Maldive Islands was molting its remiges.

Puffinus pacificus

Wedge-tailed Shearwater

Only one wedge-tailed shearwater was identified positively in the Arabian Sea, on May 17 at 17°29' N (see table 5). Some of the other dark petrels also may have been this species, but I was unable to separate them from *Bulweria fallax*, which is very similar in appearance. Several wedge-tailed shearwaters were seen as we approached the Seychelles in February, and they were numerous in this region in early June. It was common near Mauritius in February and March, and a few were seen near Reunion. Large dark shearwaters were encountered in the vicinity of the Maldive Islands in April,

but most of these seemed to be *P. carneipes*; however, 40 shearwaters seen resting on the water on Apr. 20 were identified as this species.

Puffinus griseus

Sooty Shearwater

In early April south of the subtropical convergence we encountered several dark brown shearwaters with whitish underwings, short rounded tails, and flutter-and-glide flight. They were most common near Amsterdam Island (5-6 total) but single birds also were seen at 38°01' S, 79°19' E, at 40°04' S, 75°00' E, and near St. Paul Island. I have identified tentatively these shearwaters as *P. griseus* rather than *P. tenuirostris* on the basis of the whitish as opposed to grayish underwing coloration. Neither of these species occurs regularly in the Indian Ocean though it seems likely that *P. griseus* could stray northward from the Antarctic regions, where it is abundant during migration (Oordt and Kruijt, 1953).

Puffinus assimilis

Little Shearwater

A single small, black and white shearwater with flutter-and-glide flight was seen at 33°52' S, 55°05' E, on Mar. 8. Large numbers (250+) of *P. assimilis* were found in the waters close to St. Paul Island.

Three specimens with slightly enlarged gonads were taken from the flocks feeding just off the coast of St. Paul Island on Apr. 7, 1964. The soft part colors were as follows: bill light greyish blue; feet bright blue with pink webs and some blackish on the underside; irides brown with bluish outer ring. The weights (in grams) and measurements (in mm) are included in the table below:

<i>specimen</i>	<i>sex</i>	<i>weight</i>	<i>culmen</i>	<i>wing (chord)</i>	<i>tail</i>	<i>tarsus</i>
GI-279	M	289	25	184	68	38
GI-280	?	263.5	25	184	68	38
GI-281	M	250.5	24.6	183	67.5	40.3

The two stomachs examined both contained the remains of many tiny cephalopods.

Conspicuous white edgings were present on the terminal portions of the dark grey feathers of the upperparts and in this respect, as well as mensural characters, the specimens resemble *P.a. munda* as described by Murphy (1927). George E. Watson, who kindly compared the one skinned specimen⁵ with available material, writes that it "agrees exactly with two '*munda*' collected February 16, 1926 at 49° S, 179° W by Beck and Correia (AMNH 211648, 211652).

⁵ Careful comparison of the three specimens before preservation revealed no differences in plumage pattern or coloration.

Very similar but lacking the white tipping are a *kempi* from Chatham Island, May 1892 (USNM 208603), and an *elegans* from Nightingale Island, November 1950 (AMNH 648710)." A new subspecies, *P.a. myrtac*, with distinct white feather edgings, however, has been described recently (Bourne, 1959) and it appears that immatures and fresh-plumaged adults frequently possess white feather edgings that soon wear off (Bourne, 1959; Palmer, 1962). The specimens from St. Paul fit into the complex of southern *P. assimilis* populations, but, in view of the uncertain taxonomic relationships of these shearwaters, it seems inadvisable to assign them to subspecies on the basis of the specimen material presently available.

A breeding population of *P. assimilis* has not yet been described from St. Paul Island. Jouanin and Paulian (1960) reported the species from a single subfossil tarsus and there is a recently fledged young specimen, which was collected near St. Paul Island on Jan. 26, 1956, by P. Paulian, in the collections of the Museum National D'Histoire Naturelle in Paris (Jouanin, in litt.).

Puffinus lherminieri

Audubon's Shearwater

This small shearwater was common in the vicinity of Socotra, the Seychelles, Mauritius, and Reunion Islands, but not in the intervening seas (see table 5). A flock of 15 small black and white shearwaters (*P.l. persicus?*) was also seen near the Pakistani coast between Bombay and Karachi on May 18, 1964.

Four *P. lherminieri* came aboard the *Anton Bruun* just north of the Seychelles during the evening of Feb. 11, and were collected. These specimens, however, will be included in a more comprehensive discussion of the seabirds of the Seychelles (Gill, in prep.).

Pterodroma barau

Barau's Petrel

A *Pterodroma* petrel, which I was unable to identify at the time, was fairly common in the vicinity of Reunion Island on Mar. 3 and 4, 1964. Scattered individuals, apparently of the same species were seen as far south as 27°02' S (see table 6). Subsequent observations and study of Barau's petrel on Reunion (Jouanin and Gill, MS) convinced me that I had been seeing this recently described species.

Description (from at-sea observations): upperparts light brown, primaries darker; underparts white including the undersurface of the wing, except for a narrow black band on the fore-edge of the wing becoming widest in the primaries; face white; whitish collar; tail rounded; flight with pronounced soaring and swooping, rising high on the upswing, no flapping. Especially confusing was the fact that the back appeared brown, not the characteristic grey of *P. barau* in the hand, but this undoubtedly resulted from the phenomenon whereby

grey or blackish birds at sea often appear brown against the blue of the ocean.

Pterodroma macroptera

Great-winged Petrel

Occasional individuals were seen in subantarctic waters, primarily south of Amsterdam Island (see table 3). Two dark, fast-flying petrels seen at 27°02' S, 55°49' E, on Mar. 12 may have been this species though the proximity of the location to Reunion Island also suggests the possibility of *P. aterrima*.

Pterodroma incerta

Schlegel's Petrel

Three individuals seen at 34°34' S, 69°03' E, on Apr. 2 constitute my only records of this species. Their flight consisted primarily of low gliding over the water with only occasional flapping or swooping.

Pterodroma m. mollis

Soft-plumaged Petrel

We saw this petrel commonly in subantarctic waters south of 31°31' S and recorded the highest numbers (30) at our southernmost station (see table 3). A petrel seen at 28°58' S, 55°08' E, on Mar. 6 was probably this species.

A single specimen was obtained at 40°04' S, 75°00' E, on Apr. 4. It was a male with small gonads and weighed 277.4 grams. The bill was black, the irides brown, and the feet were flesh colored, except for the outer toe and distal two-thirds of the web, which were black. The stomach contained cephalopod beaks. The measurements (in mm) were: wing 256.5; tail 115; culmen 28; tarsus 36; middle toe 45.

Pterodroma mollis is recognized easily by its small size, greyish-brown upperparts, and dark chest band against the white underparts. Its flight is fast and erratic with rapid swooping and swift, deep wing strokes, reminding one of a small jaeger (*Stercorarius*). Frequently it flies very high and then dives to the surface of the ocean, appearing to make "passes" at other birds. After dark (2100 hours) on Apr. 5, I saw a soft-plumaged petrel (made visible by the deck lights) feeding; it landed briefly on the water several times, picked up something from the surface, and then flew a short distance before repeating this procedure.

Pterodroma (leucoptera)

I saw a single, small, grey, black and white petrel on Mar. 13 at 24°10' S, 56°24' E. Apparently it was a member of the South Pacific *Cookilaria* complex though the possibility of *P. hypoleuca* could not be eliminated with certainty. Patrick J. Gould, who is familiar

with the Pacific gadfly petrels at sea, concurs in this identification after examining my field notes and sketches.

Pterodroma species

An unidentified large, greyish-brown (=grey?) petrel with a darker head and tail and white underparts was observed west of the Seychelles Islands at 05°23' S, 48°08' E, on June 1. There was a pronounced dark stripe on the upper wing surface and the underwings were white with broad black margins. The flight consisted entirely of pendulum-like swooping motions with no flapping.

Bulweria fallax

Jouanin's Petrel

In January and February medium-sized, all-dark petrels were seen regularly over most of the Arabian Sea between Bombay and Socotra. The majority of these could not be identified positively because of the difficulties involved in the separation of this species from *Puffinus pacificus* and perhaps some *Pterodroma* petrels; however, a few positive identifications of *B. fallax* were obtained and all individuals seen at close range proved to be this species; consequently, I have included here all unidentified dark brown petrels seen in the Arabian Sea from the *Anton Bruun*. Positive identifications are indicated in table 7 by an asterisk.

Using these criteria, 104 "*Bulweria fallax*" were seen during 64 hours of intensive surveillance between Jan. 27 and Feb. 10. Several small flocks (up to 50 birds) were encountered near Socotra, where the species was most common. My southernmost record was of four individuals at 00°31' S, 54°56' E, on Feb. 10.

In late May, Jouanin's petrel was the most commonly observed pelagic species on a course paralleling the Arabian coast. At least 53 *B. fallax* plus an additional 16 petrels that were either this species or *Puffinus pacificus* were seen between 22°59' N, 65°42' E, and 02°02' N, 51°11' E, in 17 hours of observation.

The flight of *B. fallax* consists of five or six quick flaps followed by a glide low over the water or a swoop down to the water from the extra height it has gained. Only occasionally does the petrel swoop in the pendulum fashion of some *Pterodroma* and, when it does, its flight hardly seems fast or erratic. The shearwater-like flight pattern seems to be used when the bird is foraging and the pendulum motion when it is travelling, though the force of the wind is also an important factor (see Bailey, 1966, p. 240). Although I saw groups of this petrel near Socotra, single individuals usually were encountered. On occasion they were seen to land on the water for extended periods of time and appeared to be feeding on squid.

Oceanites oceanicus**Wilson's Petrel**

Five scattered individuals were seen south of the subtropical convergence in early April (see table 8). None were seen in the Arabian Sea in January and February, but in May a flock of more than 50 Wilson's petrels was passed between Bombay and Karachi and still others were found near the African coast during the last week of May.

Pelagodroma marina**Frigate Petrel**

Nine frigate petrels were seen in late May between Karachi and the Seychelles Islands (see table 8). Instead of the characteristic grey, they appeared "light brown" to my eye.

Fregetta grallaria**White-bellied Storm Petrel**

Several dark storm petrels with white rumps and bellies were seen near Amsterdam and St. Paul Islands and in the waters to the south (see table 8). Although I had excellent looks at some of these, I was unable to discern any black in the middle of the white underparts. An additional 10 *Fregetta* species (probably *F. tropica*: see Bailey, 1966, p. 243) were seen in the Arabian Sea (and vicinity) between May 22 and June 2.

Oceanodroma monorhis**Swinhoe's Storm Petrel**

On two occasions (00°58' N, 55°00' E, on Feb. 9; 10°46' S, 55°00' E, on Feb. 18), I saw an all-dark storm petrel with a forked tail and very fast, erratic flight. Bailey (1965) found two species of all-dark storm petrels, the smaller of which was *O. monorhis*, verified by the capture of specimens. It seems reasonable, therefore, to assign my two observations to this species.

Oceanodroma matsudairae**Matsudaira's Storm Petrel**

Scattered individuals (12 total) of an unidentified storm petrel were seen between latitudes 07°17' N and 21°00' S; over one-half of these observations were made near the equator (see table 9). This petrel was the size of a large *Oceanodroma* (or *Bulweria bulweria*) but was not nearly as large as *B. fallax*. It was entirely dark brown in color though some individuals had conspicuously paler upper wing coverts. The flight was deliberate, almost sluggish, consisting of four or five deep wing strokes followed by a short glide with the wings bowed downward. The tail appeared either square or slightly forked.

Bailey (1964, 1965) observed a large *Oceanodroma* commonly in the vicinity of the equator from March to May 1964 and suggested that it was *O. matsudairae* from the Pacific. Since then, two specimens confirming this tentative identification have been collected in the

Indian Ocean off Western Australia by Pocklington, Willis, and Palmieri (unpubl.).

Phaëthon aethereus

Red-billed Tropicbird

In late January and early February this tropicbird was fairly common in the western Arabian Sea east to 69°11' E and south to 11°01' N, often very far from land (see table 10). In late May, five were seen only 17°29' N, 62°31' E, and three at 02°02' N, 51°11' E. No other species of tropicbirds were identified in this region.

Phaëthon lepturus

White-tailed Tropicbird

White-tailed tropicbirds were first encountered at 08°42' S, 55°07' E, on Feb. 17 and were not seen south of 24° S on this transect of the cruise (see table 11). On the 75° E transect the first one was seen at 16°42' S; we noted the species at only two of the remaining stations to the north. Many white-tailed tropicbirds were present near the the Seychelles Islands on June 2.

Sula dactylatra

Masked Booby

Scattered individuals were seen in the southwestern Arabian Sea and near the Seychelles Islands in January–February and again in late May (see table 10).

Sula leucogaster

Brown Booby

Four adults were seen near Socotra, one at 14°40' N, 55°25' E, on Feb. 1 and three at 11°30' N, 52°53' E, on Feb. 4.

Fregata ariel

Lesser Frigatebird

I saw this species only twice; three at 07°02' S, 55°11' E, on Feb. 16, and two near the Seychelles Islands on June 2.

Lobipes lobatus

Northern Phalarope

Ten northern phalaropes were seen near the Indian coast (17°44' N, 69°11' E) on Jan. 27.

Catharacta skua

Skua

A single individual was seen five miles west of Mauritius on Mar. 2. Three skuas were observed at St. Paul Island on Apr. 7.

Larus fuscus

Lesser Black-backed Gull

Several were seen near the Gulf of Aden, one on Feb. 2 and five on Feb. 3.

Larus hemprichii

Aden Gull

Two, possibly three, individuals were seen in the Gulf of Aden on Feb. 1–2.

Larus brunneicephalus

Indian Black-headed Gull

A flock of 12 was passed about 75 miles east southeast of Bombay on Jan. 27.

Sterna vittata tristanensis Murphy

Antarctic Tern

This tern was common near both St. Paul and Amsterdam Islands, where flocks of up to 100 individuals were seen just offshore.

Thirteen specimens in molt and nonbreeding condition were collected, one at St. Paul Island on Apr. 7 and the rest at Amsterdam Island on Apr. 8. In addition to winter-plumaged adults, they include several heavily barred immatures. Measurements of the skins from Amsterdam Island are included in table 12. Although the wings of this series are small (cf. Murphy, 1938), the culmen and tarsus lengths seem sufficient to separate this race from the smaller *S. v. vittata*, which breeds on Kerguelen. Of 10 stomachs examined, four contained tiny cephalopods, four contained fish, one had both fish and cephalopods, and one contained the remains of small crustacea.

Sterna repressa

White-checked Tern

Common at sea between Bombay and Karachi on May 18.

Sterna anaethetus

Bridled Tern

Seen at sea only in the vicinity of the Seychelles Islands on June 2.

Sterna fuscata

Sooty Tern

Although sooty terns were absent from the Arabian Sea south to the Seychelles in January and February, large flocks were seen 200–300 miles east of the Somalian coast of East Africa (between 06°46' N, 55°00' E, and 06°05' S, 42°11' E) and east to the Seychelles Islands in late May (see table 11). Sooty terns were common near Mauritius in February and March, and scattered individuals and flocks were seen near the Chagos and Maldive Islands in late April.

Thalasseus bergii

Crested Tern

Five *Thalasseus* terns were seen at 06°05' S, 42°11' E, on May 31 and a single *T. bergii* was observed near the Seychelles on June 2.

Anous stolidus

Common Noddy

Common noddies were numerous near both the Seychelles Islands and Mauritius, but only two individuals were seen at sea, one at 00°27' S, 54°57' E, on Feb. 10 and the other at 22°51' S, 54°58' E (southwest of Reunion), on Mar. 4.

Gygis alba

Fairy Tern

Fairy terns were seen close to the Seychelles Islands in both February and June.

In early February between $08^{\circ}00'$ N and $00^{\circ}49'$ S on the 55° E transect, a species of tern was noted flying around the *Anton Bruun* at night (see table 13). Using spot lights, we obtained good observations, discerning an *all-white* tern with a slightly forked tail that left, in my opinion, little doubt as to the identity. The birds were quite vocal, emitting short, low notes, especially when two were together. The presence of fairy terns so far out to sea and only at night (none were seen during the daytime watches) is surprising, for the nearest possible source of these birds, the Seychelles Islands, was well over 600 miles to the south and *Gygis* is usually known as a coastal or inshore species, not a pelagic one (Murphy, 1936). One wonders, however, whether scattered individuals were drawn to and concentrated around the ship at night, thereby becoming conspicuous, and also whether the species might not be as highly nocturnal as the huge eyes and pure white plumage suggest. These observations should remain hypothetical pending future confirmation.

Discussion

The distribution of seabird species and numbers is related to oceanographic factors that produce a suitable variety and abundance of food items (Jespersen, 1929; Hutchinson, 1950; Murphy, 1936). Although the data presented in this paper are insufficient in themselves, it is hoped that the total information gathered during the International Indian Ocean Expedition eventually will provide the basis for a detailed analysis of the factors underlying seabird distributional patterns in the Indian Ocean. A noteworthy step in this direction has been made recently by Bailey (1966) for the important region of upwelling off the southern Arabian coast. The rest of the Indian Ocean, however, awaits comparable attention.

One of the conclusions that is readily apparent from the data presented in this paper is the paucity of seabirds in the major part of the western Indian Ocean. In this respect, the Indian Ocean is similar to other tropical oceans, which are characterized by the relative infertility of their waters and a consequent scarcity of seabirds, except in the vicinity of land, either islands or continental coasts, and regions of local enrichment. It was only in the western Arabian Sea and below the subtropical convergence, regions where upwelling, cooler surface temperatures or other factors permit nutrient replenishment and continued productivity, and near the Seychelles and Mascarene Islands, which provide land necessary for breeding and roosting, that seabirds were at all numerous. But even the maximum numbers (200+/hour) I recorded in these regions were certainly small compared to what is possible in other parts of the world ocean (see Murphy, 1914; Oordt and Kruijt, 1955), especially

at higher latitudes. The numbers of seabirds recorded by Bailey (1966) off Arabia were also considerably greater than my counts and serve to emphasize the highly localized nature of seabird distribution in the Indian Ocean.

The composition of seabird communities often changes markedly during a year because of movements of seabirds that correspond to changes in the availability of food items and/or that are a part of extensive postbreeding migrations. In the Indian Ocean the most striking seasonal differences are those found in the western Arabian Sea (see Bailey, 1966; Bourne, 1960, 1963; Jouanin, 1957). In this area there is, first of all, a resident seabird community, which includes no less than eight endemic forms (four species and four subspecies). The majority of its species occur primarily in the inshore waters close to breeding and/or roosting stations (Bailey, 1966) with the result that only a few, e.g., *Bulweria fallax* and *Phaëthon aethereus*, are encountered regularly as far out to sea as were the stations included in this report. The presence of dark petrels, all apparently *B. fallax*, at our stations in the Arabian Sea in January and February east as far as 69°11' E suggests that Jouanin's petrel disperses widely at sea from its yet undiscovered breeding stations near the Arabian coast, at least during the nonbreeding season. Unfortunately, the southern limits of these movements remain uncertain because of the difficulty of separating it from other dark petrels. All my records were made north of the equator (actually 00°31' S), but there is a specimen from Kenya (Jouanin, 1957), and Bailey (in prep.) saw dark petrels "inseparable from *B. fallax* south to 15° S."

In May, coinciding with the onset of the monsoon winds, with the consequent offshore upwelling, and with increased productivity, the resident species of the western Arabian Sea are subjected to an influx of large numbers of several migrant species from the subantarctic Indian Ocean. Included in this arriving assemblage are three species of storm petrels: *Oceanites oceanicus* and *Fregatta tropica* from Kerguelen and the Crozet Islands (Bourne, 1960), and *Pelagodroma marina* from breeding stations off southwest Australia (Mörzer Bruyns and Voous, 1964). All of my observations are in accord with the known arrival times and distribution of these species in the northern Indian Ocean, though actual records of Wilson's petrels near the African coast may be noteworthy.

Arriving from the same area as *Pelagodroma* is the large pale-footed shearwater, *Puffinus carniceps*. Unfortunately, the majority of shearwaters I saw near the Maldive Islands in April did not come close enough to permit positive identification; however, most appeared too large, with too heavy a flight to be *P. pacificus* and consequently were considered to be *P. carniceps*. A light bill could be discerned on a

few individuals. Although large numbers do not appear until late May, pale-footed shearwaters are known to arrive in the Arabian Sea as early as mid-April (see Bailey, 1966) and, hence, records near the Maldives would not be unexpected at this time.

The status of the other dark shearwater in the Arabian Sea, the wedge-tailed shearwater, is particularly hazy because of the ease of confusion with *Bulweria fallax*. For years it was considered to be the common dark petrel in the western Arabian Sea (Alexander, 1931; Phillips, 1954) until these records were reexamined (Jouanin, 1957) in light of the discovery of *B. fallax*, which is very similar in appearance. Although a few specimens have been taken in the Arabian Sea, wedge-tailed shearwaters certainly appear to be rare there, for Bailey (1966) recorded none positively north of 10° N and I saw but one. It seems necessary, therefore, to establish just how common this species actually is in order to determine whether only occasional stragglers are involved or whether there are enough to justify postulations of either a local population or a migratory movement from another part of the Indian Ocean. The latter possibilities have been suggested (Bourne, 1960), and the idea of a local undiscovered breeding population seems especially attractive in view of several recent discoveries of small breeding populations of this species on tiny rock offshore islets, for example near Madagascar (Appert, 1965), Reunion (Jouanin, pers. comm.) and Roderigues (Vinson, 1965). In this connection also, the Maldivé Islands may harbor a population of wedge-tailed shearwaters, thereby accounting for some of the shearwaters seen at sea in that area.

Just now being established is the regular occurrence in the equatorial regions of the Indian Ocean of two storm petrels from the Pacific, *Oceanodroma monorhis* and *O. matsulirae*. Although their numbers seem to be greatest during the northern summer (Bailey, in prep.), my observations indicate that at least small numbers are present throughout the year. One cannot help but wonder if there are also undiscovered breeding populations of storm petrels in the Indian Ocean, and again the Maldivé or perhaps the Chagos Islands seem likely locations. In addition to *Oceanodroma* species, *Bulweria bulweria*, which has been recorded in the Indian Ocean (Phillips, 1959; Bourne, 1960; Jouanin, 1957), might also be sought.

Perhaps the least understood seasonal change in the western Indian Ocean are the movements of the sooty terns that breed in the Seychelles and Amirante Islands in huge numbers from May to October and that then disappear for the remainder of the year. Whether they move to other island groups, such as the Aldabras, Chagos, or perhaps Cargados Carajos Shoals, or spend these six months at sea is unknown. In February I saw no sooty terns north

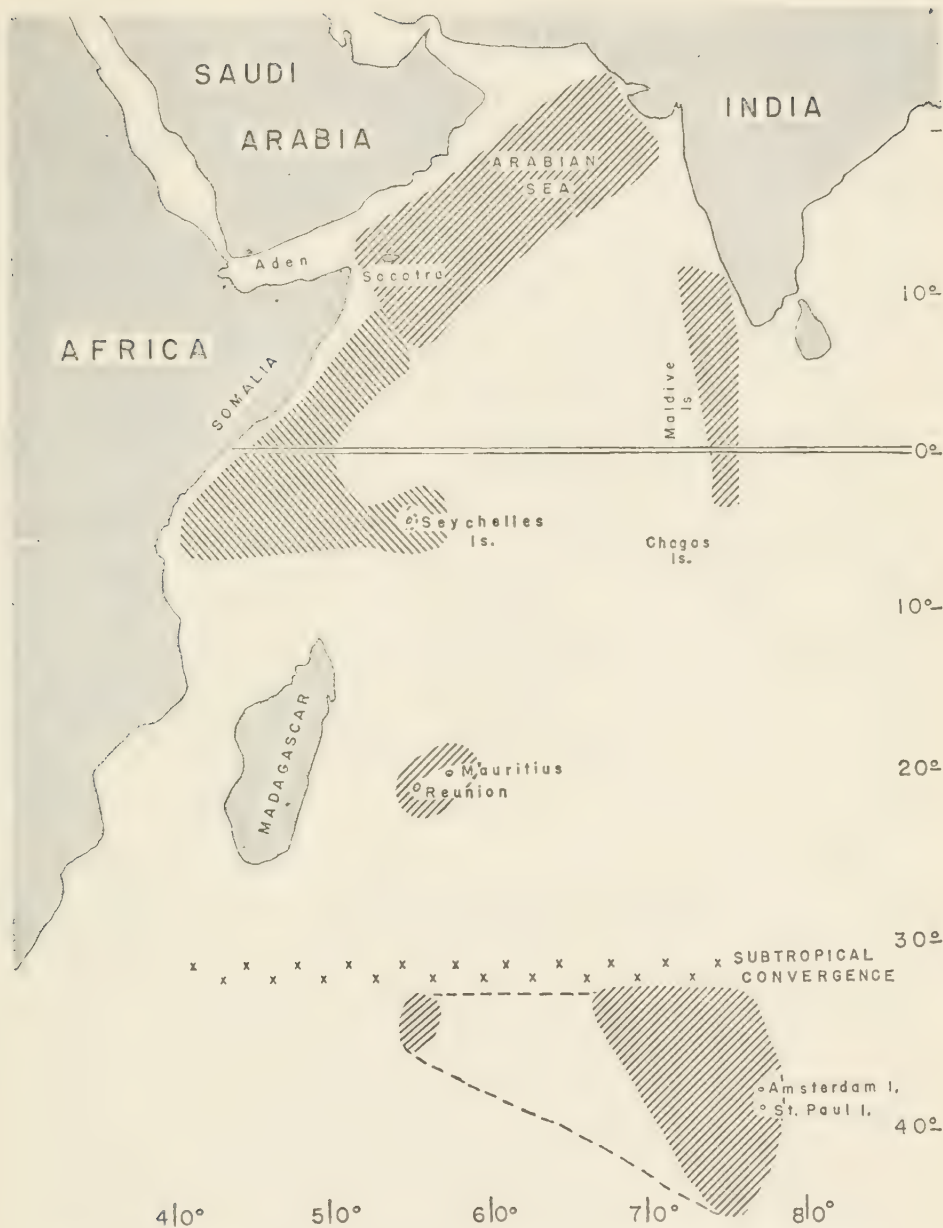


FIGURE 2.—Regions of observed seabird abundance in the western Indian Ocean.

of the Mascarene Islands on our 55° E transect, whereas in May large flocks were present at 06°46' N on this same longitude, as well as the seas south to the Seychelles and southwest to the African coast. Other observers (e.g., Bailey, in prep.) report a similar seasonality in their observations of sooty terns in this region.

The Mascarene region is of particular interest because it is the only place in the tropical or subtropical Indian Ocean where breeding

petrels of the genus *Pterodroma* are found. No less than three species of *Pterodroma* breed (or did) in the Mascarenes: the Trinidad petrel (*P. arminjoniana*) on Round Island off the north coast of Mauritius; Barau's petrel (*P. barau*) and the little known Mascarene petrel (*P. aterrima*), presumably on Reunion. This latter species is apparently extinct as it has not been seen alive in this century (Bourne, 1965) and was not found during an intensive search for petrels on Reunion in 1964 (Jouanin and Gill, MS). Barau's petrel is the most recently described species of petrel (1964), despite its being a fairly common species on Reunion; however, it is not known whether this petrel remains near Reunion throughout the year or disperses to sea in some direction during the nonbreeding season (austral winter). It does appear to confine its pelagic activities during the breeding season to the south and west of Reunion Island, as none were seen to the north or immediately to the east by either Roger Bailey or myself. Since the tropical convergence in the western Indian Ocean is located at approximately the same latitude as the Mascarene Islands (Baker, 1965), these observations suggest that Barau's petrel feeds primarily in subtropical waters. Similarly, the location of the only other breeding population of *Pterodroma a. arminjoniana* (on Trinidad Island in the South Atlantic) at almost precisely the same latitude as the Mascarene population might imply a dependence on the proximity of subtropical waters, but unfortunately this species rarely has been noted at sea.

Oceanographically, the position of the subtropical convergence, where cooler subantarctic waters sink below the warm water mass of the central (tropical) ocean, delimits the southern boundary of the Indian Ocean (Sverdrup, Johnson and Fleming, 1942). This is a *region* rather than a well-marked line and generally is considered to lie at about 40° S. Ornithologically it is of interest because it seems to coincide with the northern limits of the distributions of a variety of procellariiform species. Our northernmost records of certain southern petrels, such as the white-chinned petrel and soft-plumaged petrel, were at 31° S; nevertheless, these species were found primarily south of 34° S as were the majority of others including the albatrosses. On a transect in early July, comparable to our 55° E transect, Rand (1962) also encountered the first southern petrels at about 30° S and noted a marked increase just below 35° S; however, the numbers of individuals and the variety of species he recorded were slightly greater than ours and, in addition, he found them as far north as 26° S at stations closer to the African coast. The surface water temperatures recorded by Rand averaged several degrees lower than our measurements.

Although many of the species encountered by Rand below 30° S were the same as we found, there were several important differences. Conspicuous by their absence on our March–April cruise were Cape pigeons (*Daption capense*) which were the “most abundant of small petrels” on his cruise in June–July. Also, on a previous cruise of the *Anton Bruun* through these latitudes in September (1963) Cape pigeons were common (P. Willis, pers. comm.). On the other hand, Rand saw few white-chinned petrels (*Procellaria aequinoctialis*) except near the African coast, whereas in March and April this was a predominant species at our southern stations. Similarly, the soft-plumaged petrel (*Pterodroma mollis*), which was a common species at our stations, was not even recorded by Rand. It is unfortunate that so few detailed reports of seabird species and numbers are available for this region as there seem to be marked seasonal fluctuations in the composition, distribution, and perhaps size of its seabird community. Some of these may be related only to reduced pelagic activity during the breeding season but others may be correlated with seasonal changes in productivity. Also interesting would be an elucidation of the subtropical convergence’s role in limiting seabird distribution.

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TABLE 1.—*Seabird numbers recorded during standardized watch periods (station=HIOE Oceanographic Station, Anton Bruun; A=Procellariiformes; B=Pelecaniformes; C=Charadriiformes)*

Date	Locality	Sta. No.	Water temp. (° C)	Time	A	B	C	Birds/Hr.
Jan. 27	17°44' N, 69°11' E	-	-	0900-1100	6	4	22	16
" 28	17 12 N, 67 00 E	-	-	0755-1045	6	2	0	2.5
" 29	16 13 N, 63 29 E	282	25.2	0830-1130	2	1	0	1
" 30	15 42 N, 60 52 E	283	25.1	0830-1100	2	2	0	1.6
" 31	15 22 N, 58 12 E	284	23.9	0830-1130	3	1	0	1.3
" 31	15 18 N, 57 59 E	-	-	1530-1630	12	1	0	13
Feb. 1	14 22 N, 55 18 E	285	24.0	0800-1100	4	0	0	1.3
" 2	13 50 N, 52 59 E	286	24.9	0815-1115	4	3	1	2.6
" 3	13 11 N, 50 22 E	287	24.8	0805-1105	0	0	6	2
" 3	13 08 N, 50 36 E	-	-	1600-1700	9	0	0	9
" 4	11 30 N, 52 53 E	-	-	0835-1135	80+	3	0	27
" 4	11 01 N, 53 30 E	-	-	1345-1645	7	0	16	7.6
" 5	09 28 N, 54 52 E	288	26.0	0820-1120	3	0	0	1
" 6	07 10 N, 55 05 E	289	26.5	0815-1045	4	0	0	1.3
" 6	06 52 N, 55 06 E	-	-	1730-1830	2	0	0	2
" 7	05 02 N, 55 01 E	290	26.5	0800-1100	0	0	0	0
" 8	02 31 N, 55 04 E	291	27.6	0810-1110	0	0	0	0
" 8	02 15 N, 54 57 E	-	-	1720-1820	1	0	0	1
" 9	01 03 N, 54 56 E	292	28.0	0820-1120	1	0	0	0.3
" 9	00 58 N, 54 53 E	-	-	1720-1820	2	0	0	2
" 10	00 31 S, 54 55 E	293	28.2	0820-1120	6	0	1	2.3
" 10	00 49 S, 54 49 E	-	-	1720-1820	2	0	0	2
" 11	02 51 S, 54 58 E	294	28.3	0830-1130	5	0	0	1.6
" 11	03 20 S, 55 13 E	-	-	1725-1825	6	0	6	12
" 15	Seychelles, east coast of Mahe	-	-	1730-1830	11	0	2	13
" 16	06 28 S, 55 12 E	295	29.2	0810-1110	1	0	0	0.3
" 17	08 42 S, 55 07 E	296	28.4	0800-1120	2	2	0	1.3
" 17	09 02 S, 55 13 E	-	-	1720-1820	0	0	0	0
" 18	10 47 S, 55 15 E	297	28.9	0800-1100	3	0	0	1
" 19	12 33 S, 54 33 E	298	28.4	0840-1140	1	1	0	0.6
" 19	13 04 S, 54 37 E	-	-	1720-1820	0	0	0	0
" 20	14 57 S, 54 43 E	299	27.6	0810-1050	0	1	0	0.3
" 20	15 34 S, 54 50 E	-	-	1720-1820	0	0	0	0
" 21	17 14 S, 54 58 E	300	28.0	0815-1115	-	1	0	0.3
" 22	Mauritius (50 to 20 miles west)	-	-	0900-1130	40	5	170	86
Mar. 2	Mauritius (0 to 30 miles west)	-	-	1430-1630	12	2	15	14.5
" 3	19 57 S, 54 58 E	301	26.8	0810-1110	4	5	4	4.3
" 3	20 34 S, 54 58 E	-	-	1745-1830	6	2	0	10.6
" 4	23 07 S, 54 50 E	302	25.8	0805-1105	9	0	1	3.3
" 4	24 07 S, 54 55 E	-	-	1730-1830	2	0	0	2
" 5	26 00 S, 54 52 E	303	25.4	0830-1130	1	0	0	0.3
" 5	26 25 S, 55 01 E	-	-	1730-1830	1	0	0	1
" 6	28 22 S, 55 02 E	304	24.8	0815-1115	0	0	0	0
" 6	28 58 S, 55 08 E	-	-	1720-1820	0	0	0	0
" 7	30 50 S, 55 09 E	305	22.4	0820-1120	1	0	0	0.3
" 7	31 25 S, 54 59 E	-	-	1720-1820	0	0	0	0
" 8	33 13 S, 55 10 E	306	21.0	0805-1125	6?	0	0	2
" 8	33 52 S, 55 05 E	-	-	1730-1845	4	0	0	3.2
" 9	35 42 S, 55 15 E	307	19.7	0800-1100	11	0	0	3.6
" 9	35 00 S, 55 16 E	-	-	1725-1825	5	0	0	5
" 12	27 02 S, 55 49 E	-	-	1730-1830	1	0	0	1
" 13	24 10 S, 56 24 E	-	-	0825-1025	1	0	0	0.5

TABLE 1.—Continued

Date	Locality	Sta. No.	Water temp. (° C)	Time	A	B	C	Birds/Hr.
Mar. 14	21°00' S, 57°00' E	-	-	0830-1130	4	1	145	50
" 14	20 40 S, 57 07 E	-	-	1220-1420	300	1	100	200
" 29	21 43 S, 57 43 E	-	-	0825-0925	0	0	1	1
" 29	22 33 S, 58 22 E	-	-	1420-1620	3	0	5	4
" 30	24 57 S, 60 09 E	-	-	0835-1035	0	0	0	0
" 31	28 44 S, 63 36 E	-	-	1415-1615	0	0	0	0
Apr. 1	31 29 S, 65 58 E	-	-	0815-1115	0	0	0	0
" 1	32 20 S, 66 47 E	-	-	1545-1645	0	0	0	0
" 2	34 21 S, 69 03 E	-	20-19.2	0830-1130	5	0	0	1.6
" 2	34 53 S, 69 37 E	-	-	1345-1445	1	0	0	1
" 3	37 55 S, 72 23 E	-	-	0800-1100	29+	0	0	10
" 3	38 01 S, 73 19 E	-	-	1400-1700	25	0	0	8.3
" 4	40 04 S, 75 00 E	308	15.0	0600-0930	92	0	0	23.4
" 5	42 23 S, 74 54 E	309	12.1	0830-1430	37	0	0	6
" 6	43 31 S, 75 27 E	-	-	0700-1600	126	0	0	14
" 7	39 48 S, 77 20 E	-	-	0845-1100	32	0	0	14
" 7	St. Paul Island (within 30 miles)	309C	-	1200-1500	300+	0	53+	120
" 8	Amsterdam Island (offshore)	309E	-	all day	120	0	150	-
" 9	37 01 S, 75 19 E	310	17.0	0630-0930	21	0	0	7
" 10	34 31 S, 74 47 E	311	19.3	0630-0930	15	0	0	5
" 11	31 26 S, 74 57 E	312	22.6	0800-1000	2	0	0	1
" 12	29 00 S, 74 51 E	313	22.5	0630-0930	1	0	0	0.3
" 13	26 27 S, 75 02 E	314	24.5	0630-0730	0	0	0	0
" 14	24 20 S, 74 52 E	315	24.7	0800-1000	0	0	0	0
" 15	21 58 S, 74 55 E	316	26.0	0830-1030	0	0	1	0.5
" 16	19 44 S, 75 20 E	317	27.0	0800-1000	0	0	0	0
" 17	16 43 S, 74 53 E	318	28.1	0825-1025	0	1	0	0.5
" 18	14 10 S, 74 55 E	319	28.3	0830-1030	1?	0	0	0.5
" 19	11 47 S, 74 42 E	320	28.8	0820-1020	0	0	0	0
" 20	09 21 S, 75 08 E	321	29.3	0810-1010	0	0	0	0
" 21	06 50 S, 75 02 E	322	29.2	0820-1020	0	0	0	0
" 22	04 11 S, 75 00 E	323	29.1	0820-1020	1	0	0	0.5
" 24-27	Maldiv Islands (Addu Atoll)	-	-	no standardized watch	-	-	-	-
" 28-30	Maldives to Cochin, India	325-327	-	no standardized watches	-	-	-	-
May 18	Bombay to Karachi	-	-	0900-1300	65	0	200+	66
" 20	22 59 N, 65 42 E	-	-	0905-1105	2	0	0	1
" 21	17 29 N, 62 31 E	-	-	0915-1245	28	4	0	91
" 22	12 05 N, 58 58 E	-	-	1400-1545	11	1	0	6.8
" 22		-	-	0910-1130	26	0	0	11.3
" 23	06 46 N, 55 00 E	-	-	1410-1530	5	0	0	3.8
" 23		-	-	0845-0945	1	0	0	1
" 24	02 02 N, 51 11 E	-	-	1400-1600	6+	0	8+	7
" 24		-	-	0925-1225	9	3	275	96
" 25	01 42 S, 45 46 E	-	-	0910-1110	10	0	500	255
" 26	Mombasa—32 miles northeast	-	-	0910-1010	1	0	0	1
" 31	06 05 S, 42 11 E	-	-	0915-1215	2	0	76	26
June 1	05 23 S, 48 08 E	-	-	0915-1215	2	1	360+	120
" 2	04 33 S, 54 17 E (Seychelles Is.)	-	-	0910-1210	11	2	226	80

TABLE 2.—*Observations of albatrosses (Diomedidae)*

Date	Location	Time	<i>Dio- medea erulans</i>	<i>Dio- medea melano- phris</i>	<i>Diomedea chloro- rhynchos</i>	<i>Dio- medea cauta</i>	<i>Phoebe- tria fusca</i>
Mar. 8	33°52' S, 55°05' E	1730-1845	1	0	0	0	0
" 9	35 42 S, 55 15 E	0800-1100	1	0	0	0	0
Apr. 3	37 55 S, 72 23 E	0800-1100	12	0	2	1	0
" 3	38 01 S, 73 19 E	1400-1700	6	0	2	0	0
" 4	40 04 S, 75 00 E	all day	20	4-5	0	2-3	10
" 5	42 23 S, 74 54 E	all day	6	1	0	0	2-3
" 6	43 31 S, 75 27 E	all day	25	2-3	0	2-3	4-5
" 7	38 48 S, 77 20 E	0845-1100	17	0	1	2	3
" 7	St. Paul Island (within 30 miles)	1200-1500	12	0	0	0	10
" 8	Amsterdam Island (off-shore)	all day	15	0	4-5	0	25-30
" 9	37 01 S, 75 19 E	all day	6	1	0	1	1
" 10	34 31 S, 74 47 E	0630-0930	1	0	4 (repeats)	0	1

TABLE 3.—*Observations of subantarctic petrels (Procellariidae)*

Date	Location	Time	<i>Procel- laria aequi- noctialis</i>	<i>Adamas- tor cinereus</i>	<i>Pterodro- ma ma- croptera</i>	<i>Ptero- droma mollis</i>	<i>Pa- chyptila species</i>
Mar. 7	30°50' S, 55°09' E	0820-1120	1	0	0	0	0
" 8	33 13 S, 55 05 E	0805-1125	8	0	0	0	0
	33 52 S, 55 05 E	1730-1845	2	0	0	0	0
" 9	35 42 S, 55 15 E	0800-1100	11	0	0	8	0
" 12	27 02 S, 55 49 E	0930	0	0	2?	0	0
Apr. 2	34 24 S, 69 03 E	0830-1130	1?	0	0	0	0
" 3	37 55 S, 72 23 E	0800-1100	10	0	0	5	0
	38 01 S, 73 19 E	1400-1700	8	0	0	4	0
" 4	40 04 S, 75 00 E	all day	30	0	1	15	5-6
" 5	42 23 S, 74 54 E	all day	10	0	1-2	3-4	20
" 6	43 31 S, 75 27 E	all day	20	1-2	6	30	30
" 7	38 48 S, 77 20 E	0845-1100	5	1	3	2	7
" 7	St. Paul Island (0-30 miles)	1200-1500	10	0	0	0	10
" 8	Amsterdam Island (offshore)	all day	40	0	4-5	4	1
" 9	37 01 S, 75 19 E	all day	7	0	0	3-4	0
" 10	34 31 S, 74 47 E	0630-0930	5	0	2?	1	0
" 11	31 26 S, 74 57 E	0800-1000	0	0	0	2	0
" 12	29 00 S, 74 51 E	0630-0930	0	0	0	1?	0

TABLE 4.—*Observations of Puffinus carneipes*

Date	Location	Time	Number
		1415	
Apr. 19	11°47' S, 74°42' E	0820-1020	1
" 22	04 11 S, 75 00 E	1200, 1800	1?
" 23	02 14 S, 75 14 E	0630-0730	1, 1
" 24	Maldive Islands (Addu Atoll, Gan Is.)		2
" 28	02 01 N, 75 13 E	1600	1 (reported)
" 29	04 49 N, 74 55 E	1400	2
" 30	06 51 N, 75 02 E	1030	4
May 3	14 48 N, 73 41 E	1200	8 (reported)
" 21	17 29 N, 62 31 E	0915-1245	3
		1400-1545	1

TABLE 5.—*Observations of tropical shearwaters (Puffinus)*

Date	Location	Time	<i>pacificus</i>	<i>therminieri</i>
Jan. 29	16°13' N, 63°29' E	0830-1130	2?	0
Feb. 1	14 22 N, 55 18 E	0800-1100	0	4
	14 09 N, 54 38 E	1830	0	1
" 2	13 50 N, 52 59 E	0815-1115	0	3
	13 51 N, 52 45 E	1600-1700	0	7
" 3	12 55 N, 50 54 E	1830	0	1
" 4	11 30 N, 52 53 E	0835-1135	0	3
	11 01 N, 53 30 E	1345-1645	0	1
" 11	02 51 S, 54 58 E	0830-1130	0	1
	03 22 S, 55 13 E	1725-1825	5	0
	03 30 S, 55 19 E	2000	0	12
" 15	Seychelles Islands (east coast of Mahe)	1700-1800	0	11
" 16	06 28 S, 55 12 E	0810-1110	1	0
" 18	10 47 S, 55 15 E	0800-1100	2	0
" 22	Mauritius—50 to 20 miles west	0900-1130	38	1
Mar. 2	Mauritius—0 to 30 miles west	1430-1630	21	1
" 3	19 57 S, 54 58 E	0810-1110	0	1
	20 34 S, 54 58 E	1745-1830	1	3
" 14	20 40 S, 57 07 E	0830	0	2
	Mauritius—20 miles south southeast	1220-1420	300	0
Apr. 20	09 00 S, 75 00 E	1500	40?	0
May 18	Bombay to Karachi	1130	0	15
" 21	17 29 N, 62 31 E	0915-1245	1	0
" 22	12 05 N, 58 58 E	1410-1530	0	1
" 24	02 02 N, 51 11 E	0925-1225	8?	0
June 2	04 33 S, 54 17 E	0910-1210	2	8

TABLE 6.—*Observations of Pterodroma barau*

Date	Location	Time	Number
Mar. 3	19°57' S, 54°58' E	0810-111	1
	20 35 S, 54 58 E	1745-1830	4
" 4	23 07 S, 54 50 E	0805-1105	9
	24 07 S, 54 55 E	1650, 1730-1830	1, 2
" 5	26 00 S, 54 52 E	0830-1130	1?
	26 25 S, 55 01 E	1730-1830	1?
" 12	27 02 S, 55 49 E	1730-1830	1?
" 13	23 41 S, 56 23 E	1230-1400	1?

TABLE 7.—*Observations of Bulweria fallax*

Date	Location	Time	Number
Jan. 27	17°44' N, 69°11' E	0900-1100	6
" 28	17 12 N, 67 00 E	0755-1045	*6
" 30	15 42 N, 60 52 E	0830-1130	2
" 31	15 22 N, 58 12 E	0830-1130	3
	15 18 N, 57 59 E	1530-1630	*12
Feb. 1	14 08 N, 54 34 E	1830	1
" 2	13 50 N, 52 59 E	0815-1115	1
	13 51 N, 52 45 E	1600-1700	2
" 4	11 30 N, 52 53 E	0835-1135	*53+
	11 01 N, 53 30 E	1345-1645	*7
" 5	09 28 N, 54 52 E	0820-1120	2
" 6	07 10 N, 55 05 E	0815-0145	4
	06 52 N, 55 06 E	1730-1830	*2
" 8	02 15 N, 54 57 E	1720-1820	1
" 9	00 58 N, 54 53 E	1720-1820	1
" 10	00 31 S, 54 56 E	0820-1120	4
May 20	22 59 N, 65 42 E	0905-1105	2
" 21	17 29 N, 62 31 E	0915-1245	*15
		1400-1545	*10
" 22	12 05 N, 58 58 E	0810-1130	*22
		1430-1530	2
" 23	06 56 N, 55 90 E	0845-0945	1
" 24	02 02 N, 51 11 E	0925-1225	1
" 25	01 42 S, 45 46 E	0910-1110	1?

*Positive identification.

TABLE 8.—*Observations of storm petrels (Hydrobatidae)*

Date	Location	Time	<i>Oceanites oceanicus</i>	<i>Pelago- droma marina</i>	<i>Fregetta</i> sp.
Apr. 2	34°24' S, 69°03' E	0830-1130	1	0	0
" 3	37 55 S, 72 23 E	0800-1100	1	0	0
	38 01 S, 73 19 E	1400-1600	1	0	1
" 5	42 23 S, 74 54 E	all day	1	0	0
" 6	43 31 S, 75 27 E	all day	1	0	1
" 7	39 48 S, 77 20 E	0845-1100	0	0	1
	St. Paul Island—within 30 miles	1200-1500	0	0	6
" 8	Amsterdam Island (off- shore)	all day	0	0	3-4
May 18	Bombay, Karachi	1220	50+	0	0
" 21	17 29 N, 62 31 E	0910-1245	0	1	0
" 22	12 05 N, 58 58 E	0910-1130	0	4	0
		1410-1530	0	0	2
" 23	06 46 N, 55 00 E	1400-1600	0	0	5
" 25	01 42 S, 45 46 E	0910-1110	6	1	2
" 26	32 miles northeast of Mombasa	0910-1010	1	0	0
" 31	06 05 S, 42 11 E	0915-1215	0	2	0
June 1	05 23 S, 48 08 E	0915-0215	0	0	1?
" 2	04 33 S, 54 17 E	0910-1210	0	0	1

TABLE 9.—*Observations of "Oceanodroma matsudairae"*

Date	Location	Time	Number
Feb. 6	07°10' N, 55°05' E	0815-1945	1
" 10	00 49 S, 54 59 E	1720-1820	2
" 11	02 51 S, 54 58 E	0830-1030	4
	03 20 S, 55 13 E	1725-1825	1
" 18	10 47 S, 55 15 E	0800-1100	1
Mar. 14	21 00 S, 57 00 E	0830-1130	2
Apr. 19	11 47 S, 74 43 E	1415	1

TABLE 10.—*Observations of Phaëthon aethereus and Sula dactylatra*

Date	Location	Time	<i>Phaëthon aethereus</i>	<i>Sula dactylatra</i>
Jan. 27	17°44' N, 69°11' E	0900-1100	4	0
		1600	2	0
" 28	17 12 N, 67 00 E	0755-1045	2	0
" 29	16 14 N, 63 27 E	0800-1130	1	1
		1500-1715	2	0
" 30	15 52 N, 60 52 E	0830-1100	4	1
	15 42 N, 60 38 E	1730	2	0
" 31	15 22 N, 58 12 E	0830-1130	1	0
	15 18 N, 57 59 E	1530-1630	0	1
Feb. 2	13 50 N, 52 59 E	0815-1115	1?	1
" 4	11 01 N, 53 30 E	1725	1	0
" 17	08 42 S, 55 07 E	0800-1120	0	1
May 20	22 59 N, 65 42 E	1400	0	1
" 21	17 29 N, 62 31 E	0915-1245	4	0
		1400-1545	1	0
" 24	02 02 N, 51 11 E	0925-1225	3	0
June 1	05 23 S, 48 08 E	0925-1225	0	1

TABLE 11.—*Observations of Phaëthon lepturus and Sterna fuscata*

Date	Location	Time	<i>Phaëthon lepturus</i>	<i>Sterna fuscata</i>
Feb. 17	08°42' S, 55°07' E	0800-1120	1	0
" 21	17 14 S, 54 38 E	0815-1115	1	0
" 22	Mauritius—50 to 20 miles west	0900-1130	5	170+
Mar. 2	Mauritius—zero to 30 miles west	1430-1630	3	13
" 3	19 57 S, 54 58 E	0810-1110	5	4
	20 34 S, 54 58 E	1745-1830	2	0
" 4	23 07 S, 54 50 E	0700-1600	1, 1 (re- ported)	0
" 13	24 10 S, 56 24 E	1030	1 (reported)	0
" 14	21 00 S, 57 00 E	0830-1130	1	145
	20 40 S, 57 07 E	1220-1420	1	100
" 29	21 43 S, 57 43 E	0825-0925	0	1
Apr. 17	16 43 S, 74 53 E	0825-1025	1	0
" 20	09 21 S, 75 08 E	1500	0	flock on horizon
" 28	01 34 N, 75 13 E	1400	1	0
" 29	03 54 N, 74 56 E	1100	0	2
" 30	06 51 N, 75 02 E	1030	1	100+
May 23	06 46 N, 55 00 E	1400-1600	0	8+
" 24	02 02 N, 51 11 E	0925-1125	0	275+
" 25	01 42 S, 45 46 E	0910-1110	0	500
" 31	06 05 S, 42 11 E	0915-1215	0	70
June 1	05 23 S, 48 08 E	0915-1215	0	360+
" 2	04 33 S, 54 17 E	0910-1210	0	180

TABLE 12.—Weights (in grams) and measurements (in mm) of *Sterna vittata*

Specimen	Age/Sex	Wing (arc)	Tail	Culmen	Tarsus	Weight
GI-315	ad. M	250	131	38	19	158.7
GI-316	imm. F	243	125	35	20.5	135.7
GI-317	ad. F	242	154	35	20	128.0
GI-318	ad. F	236	153	35	19	124.5
GI-319	ad. M	249	132	37.5	19.5	152.5
GI-320	imm. M	245	120	39.5	20.5	152.6
GI-321	ad F.	252	172	37	20	136.5
GI-322	ad. M	246	160	39	20	146.7
GI-323	imm. F	240	122	35	20	152.8
<i>S. v. tristanensis</i> ¹		258	172	36.5	19.5	
<i>S. v. vittata</i> ¹		267	139.5	33	18	

¹ Taken from Murphy, 1938, p. 16.

TABLE 13.—Observations of *Gygis alba*

Date	Location	Time	Number	Remarks
Feb. 5-6	08°00' N, 54°58' E	2200-0500	1?	reported
" 6	06 28 N, 55 04 E	2100	1+	heard several, saw one
" 7	03 54 N, 55 01 E	2100-2400	15+	heard and seen
" 8	01 59 N, 54 57 E	2100	1-2	
" 10	01 47 S, 54 56 E	2300	1	reported
" 11	03 20 S, 55 13 E	1745	6	
June 2	04 33 S, 54 17 E	0910-1210	24	

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3606

Review of the Genus *Odontodactylus* (Crustacea: Stomatopoda)

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The genus *Odontodactylus* was proposed by Bigelow (1893) as a subgenus of *Gonodactylus*, from which the former differed in having the dactylus of the raptorial claw armed with teeth. *Odontodactylus* was recognized subsequently as a full genus by Bigelow (1894).

Representatives of the genus are most abundant in the Indo-West Pacific region, but one species is known to occur in the Atlantic. Comparison of a series of *O. havanensis* from the Atlantic with specimens of *O. brevirostris* from the Indo-West Pacific in connection with a revision of the western Atlantic stomatopods suggested that the specimens were conspecific. The comparative study further suggested that some characters previously used for species recognition in the genus were unreliable and that other characters might be of more value.

The current study shows that *Odontodactylus* contains five species, of which one described herein is new.

METHODS.—The terminology of the carinae of the telson in *Odontodactylus* used herein is shown in figure 1. There are some differences between these terms and those proposed by Kemp (1913). The latter are somewhat confusing in that the anterior extension of the carina of the submedian marginal tooth is called the "intermediate";

the carina of the intermediate tooth is called the "first lateral"; and the carina of the lateral tooth is called the "lateral carina." In the present study the carinae of the marginal teeth are named for the tooth on which they occur. Thus the carina of the submedian tooth and its anterior extension are referred to as the "submedian." In *Odontodactylus* there may be one or two carinae between the median and each submedian carina; these are referred to as the "accessory median carinae." The accessory median carinae are unique to certain species of *Odontodactylus*; species in other genera, including *Pseudosquilla* Dana and *Pseudosquillopsis* Serène, have no more than one accessory median carina on each side of the median carina.

Measurements are given in millimeters. Total length (TL) is measured on the midline, from the anterior margin of the rostral plate to the apices of the submedian teeth of the telson; in the section on material, the number appearing after the number of specimens is total length. Carapace length (CL) is measured on the midline and does not include the rostral plate. The eyes of *Odontodactylus* are subglobular, with the cornea divided longitudinally by a distinct band of ocelli. Cornea length is measured along this band, cornea width across it. The width of the abdomen is measured at the fifth abdominal somite. Telson width is the greatest width; telson length is the distance on the midline from the anterior margin of the telson to the bases of the movable apices of the submedian marginal teeth. Segments of the uropodal exopod are measured along their midline.

The corneal index (CI) is obtained by dividing the carapace length by the cornea width and multiplying by 100. The abdominal width-carapace length index (AWCLI), an expression of the relative width of the body, is obtained by dividing the carapace length by the abdomen width and multiplying by 100. The relation of the lengths of the two segments of the uropodal exopod is given as the ratio obtained by dividing the length of the proximal segment by the length of the distal. In *O. cultrifer* the relative height of the median carina of the telson in males and females is expressed as the ratio of the height of the median carina to the width of the telson.

The synonymies given herein include original references as well as references published subsequent to the work of Kemp (1913). Additional older references will be provided in a synonymy of the Stomatopoda to be published in "Crustaceorum Catalogus" by L. B. Holthuis.

Most abbreviations for repositories are given in the acknowledgments below. The following abbreviations are also used in the text: AM (Australian Museum, Sydney); BLIH (Biological Laboratory of the Imperial Household of His Majesty, The Emperor of Japan). Collections from these two sources have been discussed elsewhere (Manning, 1965, 1966).

ACKNOWLEDGMENTS.—I would like to thank John Field, University of Cape Town, South Africa (UCT), for the loan of specimens; J. Forest, Muséum National d'Histoire Naturelle, Paris (MNHN), for providing working space; C. B. Goodhart, University Museum of Zoology, Cambridge (UMZ), for allowing me to examine on loan the types of *O. latirostris* Borradaile; L. B. Holthuis, Rijksmuseum van Natuurlijke Historie, Leiden (RMNH), for his advice, help on literature, and for providing working space as well as specimens on loan; R. W. Ingle, British Museum (Natural History) (BMNH), for providing working space, specimens on loan, and information on the

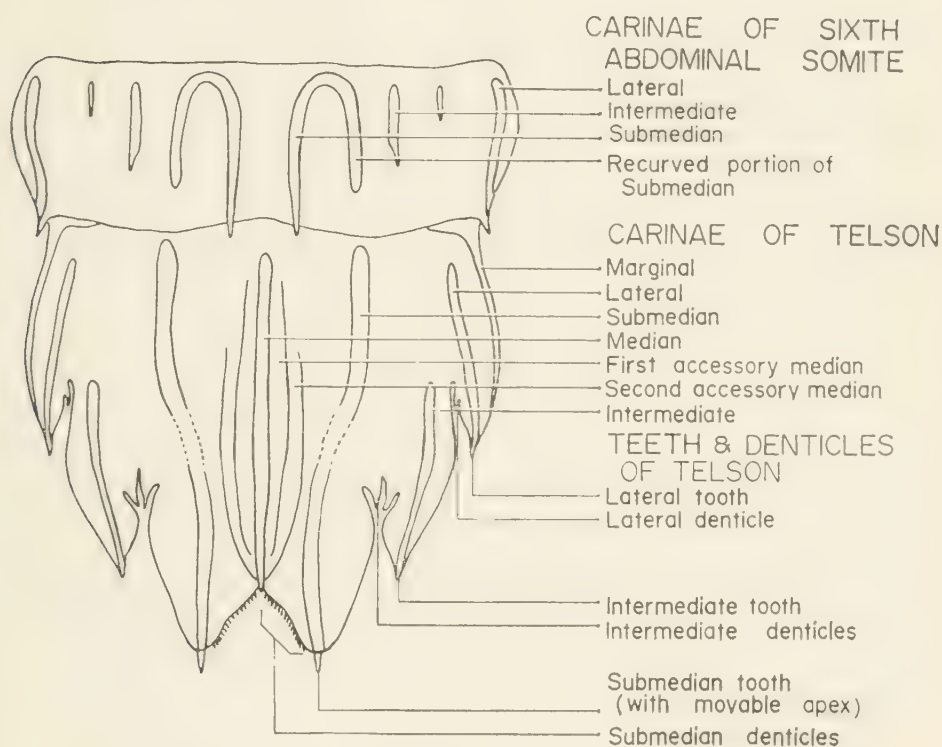


FIGURE 1.—Representative *Odontodactylus* telson indicating terms used in descriptions.

collection of *Odontodactylus* in the British Museum; J. Stock, Zoological Museum, Amsterdam (ZMA), for working space and for the loan of part of the *Siboga* collection; and T. Wolff, Universitets Zoologiske Museum, Copenhagen (UZM), for the loan of several specimens. This study was supported in part by the National Science Foundation and the Smithsonian Institution through its Research Awards program; this support is gratefully acknowledged. The illustrations are from the pen of my wife Lilly.

Odontodactylus Bigelow, 1893

Gamaris H. S., 1876, p. 275.—Holthuis, 1951, p. 86. [Suppressed by ICZN, now on Official Index, no. 122.]

Odontodactylus Bigelow, 1893, p. 100; 1894, p. 495.—Kemp, 1913, p. 133.—Hansen, 1926, p. 22.—Bigelow, 1931, p. 144.—Balss, 1938, p. 131.—Holthuis, 1951, p. 86.—Hemming, 1954, p. 155.—Holthuis and Manning, in press.—Manning, 1967, in press.

Odonterichthus Bigelow, 1894, p. 543.—Jurich, 1904, p. 396.—Gurney, 1946, p. 168 [listed; larval].

DEFINITION.—Surface of body smooth; cornea subglobular, set very obliquely on stalk; rostral plate without anterior spine; antennal protopod without papillae; carapace rounded anterolaterally and posterolaterally, without carinae; cervical groove not distinct across dorsum of carapace, position indicated on gastric grooves only; 5 epipods present; mandibular palp present; raptorial claw short, stout, dactylus inflated at base; inner margin of dactylus with teeth; propodus without proximal movable spine, superior margin not pectinate but distally serrate; ischiomer al articulation distal to terminus of merus; inferior surface of merus not ventrally channelled throughout its length for reception of propodus; endopod of walking legs elongate, 2-segmented; exposed thoracic somites without sharp carinae; abdomen semicylindrical, without sharp carinae on first 5 somites; sixth somite with 6 or more carinae but only 6 terminating in spines; telson with sharp median carina and numerous longitudinal carinae on dorsal surface; 3 pairs of marginal teeth, submedians with movable apices; submedian denticles numerous; 2 fixed intermediate and 1 fixed lateral denticle present; basal prolongation of uropod with outer spine the longer.

TYPE-SPECIES.—*Cancer scyllarus* Linnaeus, 1758, p. 633, by subsequent selection by Bigelow, 1931, p. 144 (ICZN Official List no. 731).

GENDER.—Masculine.

NUMBER OF SPECIES.—Five.

DISCUSSION.—In 1913 Kemp recognized 10 species of *Odontodactylus*, as follows: *O. scyllarus* (Linnaeus, 1758), *O. japonicus* (de Haan, 1844), *O. cultrifer* (White, 1850), *O. elegans* (Miers, 1880), *O. brevisrostris* (Miers, 1884), *O. hansenii* (Pocock, 1893), *O. carinifer* (Pocock, 1893), *O. havanensis* (Bigelow, 1893), *O. latirostris* Borradaile, 1907, and *O. southwelli* Kemp, 1911. Of these, only *O. havanensis* occurred in the Atlantic; the remainder were known only from the Indo-West Pacific.

Hansen (1926) placed four of these species into synonymy. *O. carinifer* was synonymized with *O. cultrifer*, *O. elegans* with *O. scyllarus*, and both *O. latirostris* and *O. southwelli* with *O. hansenii*.

Bigelow (1931) agreed that *O. latirostris* and *O. hansenii* were conspecific but questioned the identity of *O. southwelli* with *O. hansenii*.

Since 1913, the following taxa have been described: *O. mindanaoensis* Roxas and Estampador, 1930, from the Philippines; *O. nigricaudatus* Chace, 1942, from the Gulf of Mexico; and *O. cultrifer* var. *tridentata* Serène, 1954, from Viet Nam.

The present study shows that only four of the 14 nominal species once ascribed to this genus can be recognized as distinct species. A fifth species, from Hawaii, is described as new.

Odontodactylus now includes the following species (asterisk indicates that types of the species have been examined for this study):

<i>oldest name</i>	<i>synonyms</i>
<i>O. scyllarus</i> (Linnaeus, 1758)	* <i>G. bleekeri</i> A. Milne-Edwards, 1868 * <i>G. elegans</i> Miers, 1884
* <i>O. japonicus</i> (de Haan, 1844)	<i>G. edwardsii</i> Berthold, 1845
* <i>O. cultrifer</i> (White, 1850)	* <i>G. carinifer</i> Pocock, 1893 <i>O. mindanaoensis</i> Roxas and Estampador, 1930 <i>O. cultrifer</i> var. <i>tridentata</i> Serène, 1954
* <i>O. brevirostris</i> (Miers, 1884)	* <i>G. havanensis</i> Bigelow, 1893 * <i>G. hansenii</i> Pocock, 1893 * <i>O. latirostris</i> Borradaile, 1907 <i>O. southwelli</i> Kemp, 1911 * <i>O. nigricaudatus</i> Chace, 1942
* <i>O. hawaiiensis</i> , new species	

Kemp (1913) noted that relatively little was known about variation in adults and ontogenetic changes in members of the genus. Young specimens are quite different from adults and these differences have been the primary reason for the multiplicity of names in the genus. Original descriptions of the following species, for example, are based on postlarvae or juveniles: *Gonodactylus brevirostris*, *G. carinifer*, *G. elegans*, *G. hansenii*, and *G. havanensis*.

In *Odontodactylus* the following features used in the past to diagnose species, may change with age:

1. Eye size: The cornea is relatively smaller in adults than in juveniles. In *O. scyllarus* the CI is about 300 in specimens 25 mm long, whereas in specimens over 100 mm long the CI is in excess of 576 and as large as 750.

2. Raptorial claw: The swollen portion of the dactylus of the claw is proportionally more inflated in adults than in juveniles; further, the characteristic basal notch present on the dactylus of young specimens disappears in adults.

3. Sculpture of the last abdominal somite: In very young specimens, including postlarvae and some early juveniles, the carinae of the sixth abdominal somite are not fully developed. Apparently the

only species in which the full complement of carinae (one pair of submedians, recurved posteriorly; one pair each of intermediates and laterals) on this somite are not developed in the adult is *O. cultrifer* (White).

4. Sculpture of the telson: In specimens with a TL of less than 30 mm all the carinae of the telson may not be present. In postlarvae and early stage juveniles only the median carina and the anterior portions of the submedian carinae may be present. Young specimens also may not exhibit the same degree of development of the carinae as do the adults. In general, the two pairs of accessory median carinae are the last to develop.

5. Uropod structure: The relative lengths of the two segments of the uropodal exopod may change with increasing size. In juveniles the distal segment may only be one-half or two-thirds as long as the proximal, whereas in adults the segments may be subequal in length. The last movable spine on the outer margin of the uropod is shorter in large specimens than in small ones. The relative lengths also differ in each species; *O. cultrifer* is the only species in which the proximal segment is always shorter than the distal.

Four important characters do not change with age: (1) the position of the ocular scales, whether appressed or separate; (2) the setation of the antennal scale; (3) the number of teeth on the dactylus of the raptorial claw; (4) and the presence of posterolateral spines on the fifth abdominal somite.

Key to Species of *Odontodactylus* (Adults)

1. Ocular scales appressed along midline; telson with 2 pairs of accessory median carinae 2
 Ocular scales separate; telson with 1 pair of accessory median carinae 4
2. Fifth abdominal somite unarmed posterolaterally; telson with longitudinal carina extending anteriorly from inner intermediate denticle. *japonicus*, p. 7.
 Fifth abdominal somite with posterolateral spines; telson lacking longitudinal carina extending anteriorly from inner intermediate denticle 3
3. Dactylus of claw with less than 5 teeth; movable spines of uropodal exopod broad, inflated distally *scyllarus*, p. 10.
 Dactylus of claw with more than 5 teeth; movable spines of uropodal exopod tapering distally *hawaiiensis*, new species, p. 16.
4. Median carina of telson thin, high; dactylus of claw with less than 5 teeth; posteriorly recurved portion of submedian carinae of fifth abdominal somite absent *cultrifer*, p. 18.
 Median carina of telson not noticeably thin or high; dactylus of claw with more than 5 teeth; submedian carinae of fifth abdominal somite recurved posteriorly *brevirostris*, p. 22.

Odontodactylus japonicus (de Haan, 1844)

FIGURE 2

Gonodactylus japonicus de Haan, 1844, pl. 51 (fig. 7); 1849, p. 225 [text].—Miers, 1880, p. 116.—Gee, 1925, p. 163 [listed].

Gonodactylus Edwardsii Berthold, 1845, p. 48; 1847, p. 30, pl. 3 (fig. 6).

Odontodactylus japonicus.—Bigelow, 1894, p. 496 [key].—Borradaile, 1907, p. 212.—Kemp, 1913, p. 139.—Alexander, 1916, p. 10.—Parisi, 1922, p. 110, fig. 5.—Komai, 1922, p. 102, figs. 1–2.—Kemp and Chopra, 1921, p. 297 [listed].—Komai, 1927, p. 336, pl. 13 (figs. 3–4) [part].—Komai, Akatsuka, and Ikari, 1927, p. 295 [listed].—Komai and Ikari, 1929, p. 121.—Schmitt, 1929, p. 147 [listed].—Komai, 1938, p. 272.—Holthuis, 1941, p. 276.—Anonymous, 1945, p. 845, fig. 2428, pl. 7 [color].—Stephenson and McNeill, 1955, p. 248.—Utinomi, 1956, p. 92, pl. 46 (fig. 8) [color]; 1960, p. 114, pl. 57 (fig. 2) [color].—Stephenson, 1960, p. 61; 1962, p. 35.—Shiino, 1964, p. 291 [discussion].—Manning, 1965, p. 260.

Gonodactylus edwardsii.—Gee, 1925, p. 163 [listed].

Not *Odontodactylus japonicus*.—Bigelow, 1931, p. 145, pl. 1 (fig. 1).—Edmondson, 1946, p. 243. [= *O. hawaiiensis*, new species.]

MATERIAL.—1♀, 82.2; Saya del Malha Bank, Seychelle Is., W. Indian Ocean; 100 m; June 9, 1905; J. S. Gardiner, M. A. Caius; UMZ.—1♀, 117.0; Ambovombé, south coast of Malagasy Republic; 60 m; Oct. 28, 1958; A. Crosnier, col.; USNM 120343.—1♂, 142.0; Swatow, China; BMNH 84.2.—2 dry spec.; China; no. 167b, c; BMNH 40.3.7.17–18.—1 dry spec., CL 30.0; same; BMNH 46.114.—1 dry spec., CL 31.5; same; BMNH 49.55.—1♀, 107.0; Japan; type; RMNH 32.—1♀, ca. 141.0; Japan; Oct. 3–12, 1904; Dofflein, col.; BMNH 1910.9.30.10.—1♂; Tokyo, Japan; 1906; M. Harmand; MNHNP.—2 spec.; Yokohama, Japan; 1902; Boucard; MNHNP.—1 dry ♂, ca. 125.0; 1 broken ♀; Japan; October 1901; UZM.—1♀, 109.0; Nagasaki, Japan; May 1909; J. Jordan, col.; UZM.—1♂, 150.0; 1♀, 132.5; no locality; BLIH 134.—1♂, 130.0; Hayama, Sagami Bay; Feb. 20, 1920; BLIH 135.—1♂, 115.3; off Hayama, Sagami Bay; 55 m; Feb. 2, 1952; BLIH 658.

DESCRIPTION.—Eyes subglobular, length of cornea greater than width; eyes extending beyond end of first segment of antennular peduncle; anterior margin of ophthalmic somite truncate, not noticeably projecting; ocular scales truncate, oblique to body line, appressed along midline.

Antennular peduncle about half as long as carapace.

Antennal scale large, ovate, longer or slightly shorter than carapace; anterior margin not setose, posterior margin lined with short setae; anterior margin of dorsal plate of antennal peduncle rounded.

Rostral plate triangular, appearing trapezoidal in dorsal view;

apex depressed, longitudinally sulcate, fitting snugly behind ocular scales.

Carapace narrowed anteriorly; lateral plates projecting slightly beyond base of rostral plate.

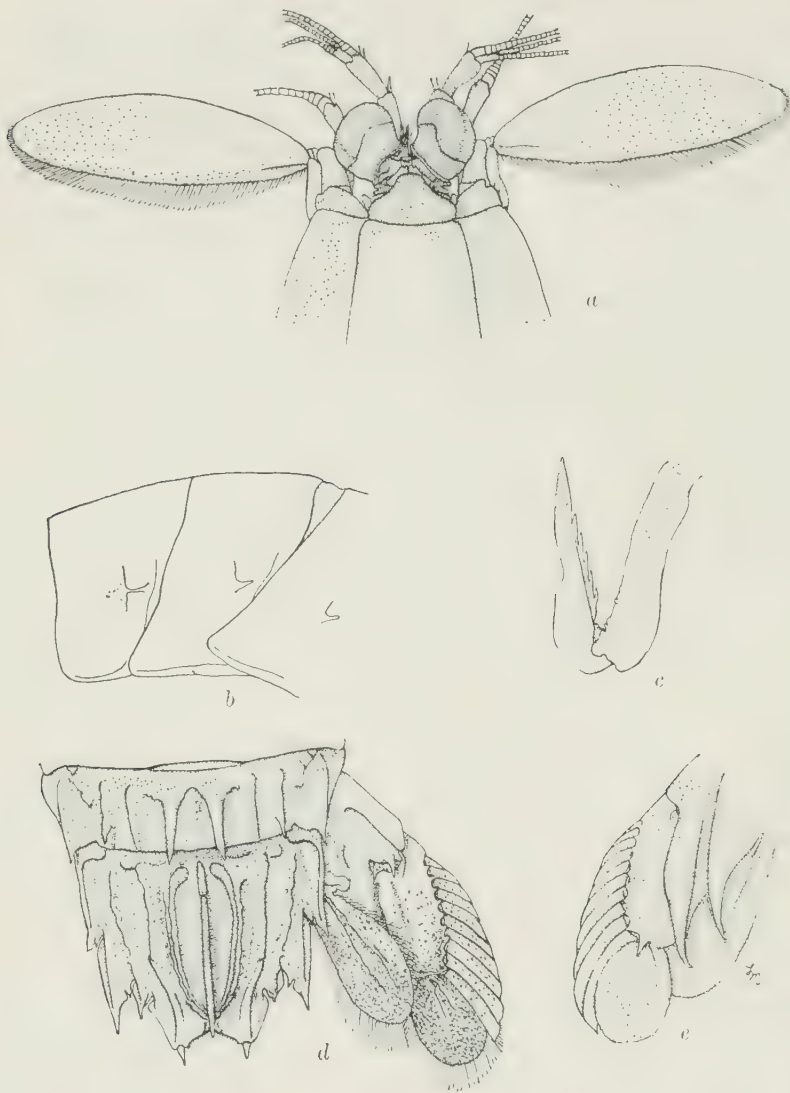


FIGURE 2.—*Odontodactylus japonicus* (de Haan), female, TL 117.0 mm, Madagascar: *a*, anterior portion of body; *b*, third to fifth abdominal somites in lateral view; *c*, propodus and dactylus of raptorial claw; *d*, sixth abdominal somite, telson, and uropod; *e*, uropod, ventral view, setae omitted.

Raptorial claw stout; dactylus armed with 6–8 teeth, outer margin of inflated basal portion rounded in large specimens.

Fifth thoracic somite lacking distinct lateral process, lateral portions of somite concealed under carapace; lateral processes of next

somites broadly rounded posteriorly, process of seventh somite larger than that of sixth; ventral keel on eighth thoracic somite broadly rounded, inclined posteriorly.

Abdominal somites smooth, strongly convex; longitudinal sulcus originating from anterolateral pit present on fifth somite, inconspicuous if present on fourth; posterolateral angles of first 5 somites rounded; sixth somite with 6 pairs of posterior spines (obsolete in large specimens), submedian carinae recurved posteriorly; anterior "knobs" present between intermediate and lateral carinae; at most a blunt lobe present in front of articulation of uropod; ventral surface of sixth somite with posterior margin concave along midline.

Telson slightly broader than long, greatest width at base, ornamented with carinae as follows: (1) median carina with short apical spine; (2) 2 pairs of accessory median carinae, inner much more prominent; (3) 1 pair of long submedians, anterior portions usually connected to posterior; (4) 1 pair of long curved carinae, extending from inner intermediate denticle almost to anterior margin of telson; (5) 1 pair of short intermediate carinae, each on tooth; (6) 1 pair of short lateral carinae, extending toward apex of the lateral tooth and fusing with the marginal carina; and (7) 1 pair of marginal carinae.

Outer margin of proximal segment of uropodal exopod with 10–12 broad, flattened, overlapping spines, last extending slightly beyond end of distal segment; distal 4 or 5 spines spatulate; proximal segment of uropodal exopod less than 1.5 times as long as distal segment; endopod broadly ovate with 2 longitudinal carinae not extending to apex; basal prolongation with outer spine the stronger, extending past proximal segment of exopod but not past endopod.

COLOR.—Komai (1922) noted that males are bright salmon red and females are salmon red anteriorly, bluish green posteriorly. None of the present specimens showed any color pattern in preservative.

SIZE.—Males, TL 125.0–150.0 mm; females TL 82.2–141.0 mm.

Measurements and indices for selected specimens of *O. japonicus* (de Haan) are as follows:

	♀	♀	♀	♀	♀	♂
Total length	82.2	107.0	109.0	117.0	141.0	142.0
Carapace length	18.2	22.9	22.1	25.1	29.7	29.7
Cornea length	5.0	5.3	5.4	5.7	6.2	6.3
Cornea width	4.3	4.5	4.7	5.0	5.7	5.7
Antennal scale length	17.9	22.3	24.0	24.2	—	31.5
Fifth abdominal somite width	18.2	22.3	23.2	25.5	30.1	29.0
Telson length	13.7	16.6	19.0	18.1	—	24.0
Telson width	14.7	18.8	19.3	21.2	—	24.6
CI	423	489	470	502	521	521
AWCLI	1000	1013	1049	1015	1013	976
Uropod P/D	1.50	1.40	1.42	1.31	1.51	1.36

DISCUSSION.—Only two species of *Odontodactylus*, *O. scyllarus* (Linnaeus) and *O. hawaiiensis*, new species, have appressed ocular scales as well as two pairs of accessory median carinae on the telson. Both of these have at least the fourth and fifth abdominal somites armed posterolaterally and neither has a dorsal carina on the telson extending anteriorly from the inner intermediate denticle. In addition, *O. scyllarus* has less than five teeth on the claw; *O. hawaiiensis* agrees with *O. japonicus* in having more than five. *O. brevirostris* (Miers) and *O. cultrifer* (White) both differ from *O. japonicus* in having separate ocular scales and only one pair of accessory median carinae on the telson.

Komai (1927) noted that some young specimens of *O. japonicus* obtained from fish stomach contents could not be sexed but morphologically resembled adults. He further noted that two specimens had posterolateral spines on the fourth and fifth abdominal somites. Inasmuch as *O. japonicus* completely lacks these spines, Komai's specimens must be referred to *O. brevirostris*. The adults reported by Komai are probably *O. japonicus*.

No sexual dimorphism of morphological characters was noted in the specimens reported herein. Komai (1922) gave an account of dimorphism in color pattern and commented on an aberrant male with a pattern approaching that of a female.

DISTRIBUTION.—*O. japonicus* has been recorded from numerous localities around Japan and China, from three localities in Australia [Broome (Alexander, 1916) and Shark Bay or Exmouth Gulf, Western Australia (Stephenson, 1962), and off Wistari Reef, Capricorn Group, Queensland (Stephenson, 1960)], and from two localities in the Indian Ocean, south of the Seychelles (Borradaile, 1907) and the present record from Madagascar, in shallow water to 100 m.

Odontodactylus scyllarus (Linnaeus, 1758)

FIGURE 3

Cancer Scyllarus Linnaeus, 1758, p. 633.

Cancer scyllarus.—Linnaeus, 1767, p. 1054.—Holthuis, 1951, p. 86 [discussion].—Hemming, 1954, p. 158.—Holthuis and Manning, 1964, p. 139.

Gonodactylus scyllarus.—Latreille, 1828, p. 473.—H. Milne-Edwards, 1837, p. 529.—Miers, 1880, p. 115; 1880a, p. 459.—Bigelow, 1893, p. 100 [discussion].

Gonodactylus Bleekerii A. Milne-Edwards, 1868, footnote p. 65.—Miers, 1880, p. 118.

Gonodactylus elegans Miers, 1884, p. 566, pl. 52 (figs. B, b).

Odontodactylus bleekerii.—Bigelow, 1894, p. 496 [key].

Odontodactylus elegans.—Bigelow, 1894, p. 496 [key].—Kemp, 1913, p. 139.

Odontodactylus scyllarus.—Bigelow, 1894, p. 496.—Kemp, 1913, p. 135 [older references].—Bouvier, 1915, p. 312.—Sunier, 1918, p. 11.—Kemp and Chopra, 1921, p. 297 [listed].—Hansen, 1921, p. 79; 1926, pp. 22, 42 [larvae], pl. 2 (fig. 6).—Komai, Akatsuka, and Ikari, 1927, p. 295 [listed].—Komai and Ikari,

1929, p. 121.—Roxas and Estampador, 1930, p. 114.—Gravier, 1937, p. 200, figs. 17–19.—Serène, 1937, p. 68 [listed].—Komai, 1938, p. 271.—Serène, 1939, p. 349 [discussion].—Holthuis, 1941, p. 275.—Ward, 1942, p. 56.—Anonymous, 1949, p. 845, fig. 2429 [color].—Holthuis, 1951, p. 86.—Dawydoff, 1952, p. 145.—Stephenson, 1953, p. 46.—Serène, 1953, p. 507; 1954, pp. 6, 10.—Stephenson and McNeill, 1955, p. 248.—Utinomi, 1956, p. 92, pl. 46 (fig. 7).—Barnard, 1956, p. 22.—Kalk, 1958, pp. 75, 83.—Holthuis, 1959, p. 119, photo 10 (fig. 4).—Utinomi, 1960, p. 114, pl. 57 (fig. 3).—Serène, 1962, fig. 1E1.—Stephenson, 1962, p. 35.

MATERIAL.—1 broken ♂; Kilifi, 48 mi. north of Mombasa, Kenya; Mrs. G. Harvey; BMNH 1956.11.1.—1 ♂ 137.5; Zanzibar; BMNH 68.32.—1 spec., 23.5; Purse Is., Iles des Roches, Amirante IIs.; *Alert*; syntype of *Gonodactylus degans*; BMNH 183.—1 ♂, 128.8; Seychelles; E. P. Wright; BMNH 75.20.—1 spec., ca. 22.8; Providence Is., north of Malagasy Republic; *Alert*; syntype of *Gonodactylus degans*; BMNH 215.—2 spec.; Malagasy Republic; G. Petit; MNHNP.—1 ♂, 161.0; same; BMNH 63.31.—1 broken, 1 ♂, CL 36.0; Nosy Bé, Malagasy Republic; A. Crosnier; USNM 120342.—1♀, 135.2; Inhassaro, Mocambique; 1965; UCT.—1♀, 144.0; Mauritius; de Belloquet; MNHNP.—1 ♂, 87.0; same; Desjardins; MNHNP.—1 dry ♂, 158.0; same; BMNH 167a.—1 dry spec., CL 33.7; same; BMNH 42.66.—1♀, 74.0; Christmas Is.; C. W. Andrews; 1908; BMNH 1909.5.19.284.—1 ♂, 85.6; Poeloe Weh [north of Sumatra?]; P. Buitendijk; January 1911; RMNH 45.—1 spec.; Djakarta [Batavia], Indonesia; Bleeker; type of *G. bleekeri*?; MNHNP.—2♀, 74.3–85.5; harantoeka Flores, Indonesia; 1891; RMNH 1.—1 ♂; Lamakera, Lessa Sunda IIs.; Laurence; Dec. 21, 1909; ZMA.—1♀, 62.9; reede v. Koepang [Kupang?], Timor; Hendrickse; July 5, 1909; ZMA.—1 ♂, 99.3; New Guinea; BMNH 80.6.—1 ♂, 107.9; 1♀, 119.2; Banda; Semmelinck; 1841; RMNH 14.—1♀; Banda; van der Velde; ZMA.—1♀, 25.2; Banda anchorage; lithothamnion bank, 6–36 m; *Siboga* Sta. 240; Nov. 23–Dec. 1, 1899; ZMA.—2 ♂, 1♀; Ambon [Amboina]; W. Gerooms; 1913; ZMA.—2 ♂, 123.0–133.2; same; BMNH 80.6.—8 ♂, 111.0–141.0; 4♀, 98.5–140.5; same; H. Ludeking, 1863; L. M. Hoedt, 1864; RMNH 3.—3♀ [2 lots]; Moluccas; v. d. Hucht; 1858; ZMA.—4 spec.; Elat, west coast of Great Kei Is., Moluccas; reef; *Siboga* Sta. 261; Dec. 16–18, 1899; ZMA.—1♀, CL 25.7; Lette Is., Timor; BMNH 80.6.—1♀, 25.0; Puerto Galera, Mindoro, Philippines; Th. Mortensen; Mar. 2, 1914; UZM.—1♀, 129.4; Calapan, Mindoro, Philippines; P. de Mesa; December 1932–January 1933; MCZ 9616.—1♀, CL 26.5; Baie de Lovane, Viet Nam; Dawydoff; April 1933; MNHNP.—1 ♂, 108.7; Tutuila, American Samoa; Smithsonian Institution Pacific Project; Feb. 23, 1965; USNM 120264.—1 ♂, 160.0; Samoa; BMNH 75–67.—1♀, 142.0; same; A. B. Steinberger; USNM 5147.—1 ♂, 124.0; Rotuma, Fiji IIs.; J. S. Gardiner; UMZ.—

1 ♂, 53.9; Vanikoro, Santa Cruz IIs.; Templeton Crocker Expedition; June 5, 1933; USNM 120265.—1 ♀, 109.2; New Britain; Willey; 1895–1897; UMZ.—1 ♂, 109.0; Blanche Bay, New Britain; A. Willey; July 1895; BMNH 1918.2.25.1.—1 ♀, 103.2; Ifaluk Atoll, Caroline IIs.; Abbott and Yaniseiman, No. 643; Oct. 19, 1953; USNM 104702.—1 ♂, 143.5; Wakanoura, Japan; Jordan and Snyder; 1900; USNM 26346.

DESCRIPTION.—Eye subglobular, cornea small, length greater than width; eyes extend to or slightly beyond end of first segment of antennular peduncle; anterior margin of ophthalmic somite truncate, not noticeably projecting; ocular scales truncate, oblique to body line, appressed along midline.

Antennular peduncle shorter than carapace.

Antennal scale large, ovate, not as long as carapace; anterior surface of scale almost completely setose, anterior setae much shorter than posterior; dorsal plate of antennal peduncle quadrangular, anterior margin irregularly rounded or subtriangular.

Rostral plate triangular, short, not extending anteriorly past ocular scales; lateral margin rounded; apex may fit in space behind ocular scales; apex sharp, depressed, anterior half or third sulcate.

Carapace narrowed anteriorly, lateral plates projecting anteriorly just past base of rostral plate.

Raptorial claw stout; dactylus armed with 2–3 teeth, outer margin of swollen portion flattened, smooth or irregular.

Mandibular palp and 5 epipods present.

Fifth thoracic somite lacking distinct lateral process, entire somite usually concealed under carapace; lateral processes of next 2 somites irregularly rounded, process of seventh more rounded than sixth; ventral keel on eighth thoracic somite low, inclined posteriorly, broadly rounded or obliquely truncate.

Abdominal somites generally smooth; second to fifth with lateral longitudinal groove originating from anterior pit, increasing in sharpness posteriorly, upper and lower borders actually carinate on fifth somite; third to fifth or fourth and fifth somites with posterolateral spines, that of fifth somite largest, carinate; submedian, intermediate and lateral carinae of sixth somite with posterior spines; submedian carinae recurved posteriorly; prominent knobs present on anterior half of somite between intermediate and lateral carinae; no spine in front of articulation of uropod; ventral surface of sixth somite with bilobed posterior margin, median emargination present between lobes.

Telson broader than long, greatest width at apices of lateral teeth, ornamented with carinae as follows: (1) median carina with short posterior spine; (2) 2 pairs of accessory median carinae, inner longer, which converge under posterior apex of median carina, outer accessory

medians forming inconspicuous knob; (3) carinae of submedian teeth not always continuous with anterior submedians; (4) short subparallel

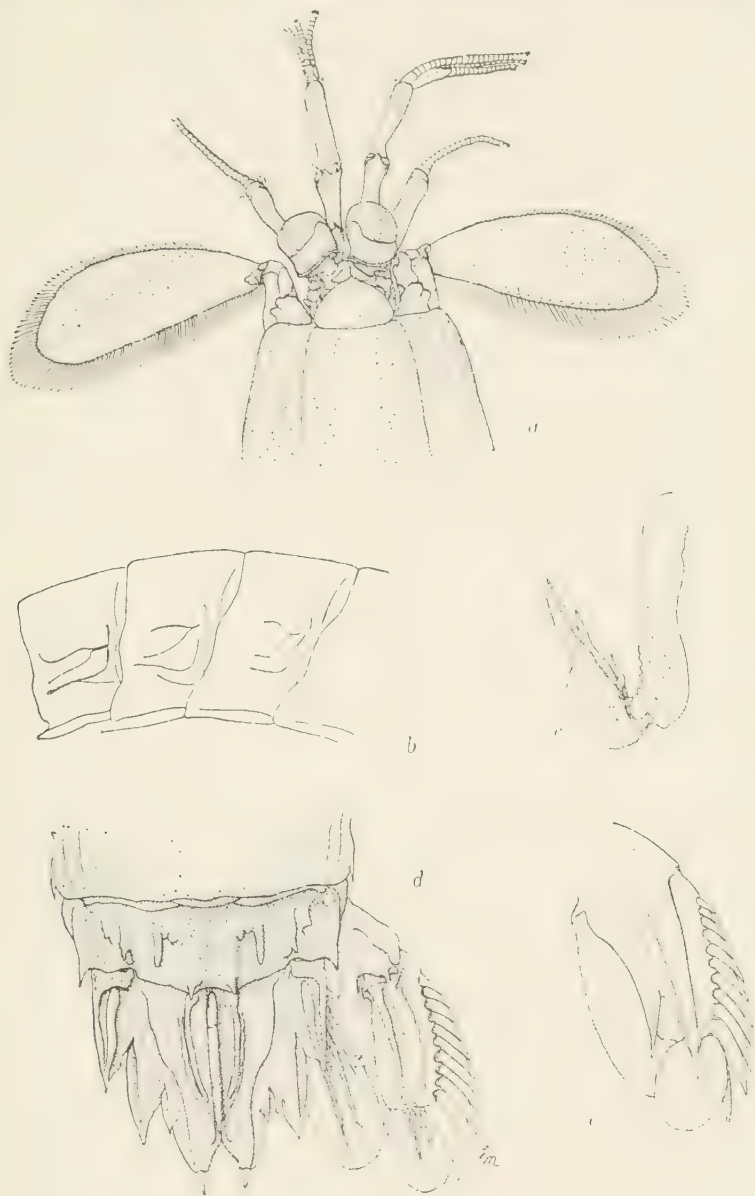


FIGURE 3.—*Odontodactylus scyllarus* (Linnaeus), female, TL 103.2 mm, Ifaluk Atoll: *a*, anterior portion of body; *b*, second to fifth abdominal somites, in lateral view; *c*, propodus and dactylus of raptorial claw; *d*, sixth abdominal somite, telson, and uropod; *e*, uropod, ventral view (setae omitted in *d* and *e*).

carinae present on inner side of submedian teeth; (5) short, swollen anterior margin on each large intermediate denticle; (6) carina of intermediate tooth not extending anteriorly much past base of tooth;

and (7) lateral carinae, each of which fuses with marginal carina at apex of lateral tooth.

Outer margin of penultimate segment of uropodal exopod with 10-11 broad, flattened, overlapping spines, last not extending to distal margin of rounded distal segment; proximal segment of exopod less than twice length of distal segment; endopod broadly ovate, with 2 dorsal longitudinal carinae that do not extend to apex; basal prolongation with outer spine longer than inner but not extending past apex of endopod.

COLOR.—In preservative, ventral surface and lateral portions of body darker than upper; dactylus of claw orange; antennal scale with distal black spot; anterior portions of carapace with irregular oval areas outlined in dark pigment, especially on lateral plates; basal segment of uropods yellow, distal segments black, apices of movable spines pink. Although much of the color and pattern fade in preservative, the oval spots on the carapace may persist for sometime.

SIZE.—Males, TL 53.9-171.0 mm; females, TL 22.8-144.0 mm.

Measurements and indices for selected specimens of *O. scyllarus* (Linnaeus) are as follows:

MALES								
Total length	53.9	87.0	97.5	108.7	124.0	—	143.5	160.0
Carapace length	12.0	21.6	22.5	26.0	27.5	36.0	37.0	39.0
Cornea length	3.4	4.6	4.7	5.0	4.7	5.7	5.7	5.7
Cornea width	2.8	3.9	4.2	4.1	4.2	4.7	5.5	5.2
Antennal scale length	10.0	17.6	18.7	21.6	22.0	28.8	28.7	30.3
Fifth abdominal somite width	11.6	20.8	22.3	26.5	26.1	35.0	34.5	36.6
Telson length	9.0	15.6	17.2	19.7	19.2	26.1	27.6	—
Telson width	9.4	17.6	17.7	21.2	22.2	29.3	28.9	—
CI	429	553	536	634	655	766	673	750
AWCLI	966	962	991	1019	949	972	932	938
Uropod P/D	1.39	1.75	1.79	1.43	1.89	1.65	1.52	1.88
FEMALES								
Total length	25.2	25.0	74.0	103.2	—	129.4	144.0	142.0
Carapace length	5.7	6.1	17.4	24.5	26.5	29.7	32.6	33.2
Cornea length	2.1	2.3	4.5	4.5	4.9	5.1	5.2	5.4
Cornea width	1.9	2.0	3.7	3.9	4.6	4.5	4.8	4.7
Antennal scale length	3.3	4.0	15.8	19.8	21.4	22.8	26.6	27.0
Fifth abdominal somite width	4.9	5.8	17.3	24.1	26.2	29.8	32.7	32.5
Telson length	3.8	4.1	14.2	18.1	—	22.7	25.3	26.0
Telson width	4.1	4.7	14.5	19.2	—	23.7	26.5	26.2
CI	300	305	470	628	576	660	679	706
AWCLI	859	950	994	983	988	1003	1003	978
Uropod P/D	1.62	1.88	1.63	1.60	1.80	1.64	1.78	1.56

DISCUSSION.—*O. scyllarus* can be distinguished from all other species in the genus by the presence of only two or three teeth on the dactylus of the claw and the presence of a full complement of carinae on the telson, including two pairs of accessory median carinae.

Kemp (1913) was correct in synonymizing *Gonodactylus bleekeri* A. Milne-Edwards, 1868, with *O. scyllarus*. Milne-Edwards' account included no mention of features that might distinguish his species from *O. scyllarus*, even though he mentioned the latter species in his discussion. A specimen in the Paris Museum collected by Bleeker in Batavia [Djakarta] is probably the type of *G. bleekeri* although it is not so labelled. It appears to be a normal *O. scyllarus*.

Hansen (1926) was the first to synonymize *G. elegans* Miers, 1884, with *O. scyllarus*. I have examined the types of *O. elegans*, two postlarvae or early juvenile females, and concur with Hansen. Although the carinae of the telson are poorly developed in those specimens, they may be well developed in other specimens of similar size.

Adults of *O. scyllarus* have smaller eyes than adults of any other species in the genus, and, as usual, the eyes in juveniles are comparably larger than in adults. In specimens of the "*elegans*" stage, the corneal index is 300, whereas in adults it ranges from 470 to 766.

Odontodactylus scyllarus was originally described by Linnaeus (1758, p. 633) as follows:

Sylla- 55. C. macrourus articularis, manibus adactylis ventricosis rectis angulatis introrsum tridentatis. *Mus. Ad.*

rus. Fr. I. p. 86. C. mirabilis.

Rumph. mus. t. 3. f. F. G.

Habitat in M. Asiatico.

Statura praecedentis. Thoracis testa latere postico

emarginata. Mucronum par pone pedes.

As Holthuis (1959) pointed out, Rumphius' figure F on plate 3 is *O. scyllarus*, but figure G is the dactylus of a *Gonodactylus* since no teeth are shown on the terminal segment. In order to settle the identity of *O. scyllarus*, the specimen figured by Rumphius (1705) on plate 3, figure F, is here selected as the lectotype of the species.

REMARKS.—As in *O. brevirostris* (see below), there is some overlap in size between postlarvae and first stage of juveniles; Hansen (1926) commented on this in his account of *O. scyllarus*.

RANGE.—Through most of the Indo-West Pacific in shallow water; it is often found on coral reefs. There are no records from the Red Sea, South Africa, or Hawaii, but there are scattered records from many localities between East Africa and Japan.

Odontodactylus hawaiiensis, new species

FIGURE 4; PLATE 1

Odontodactylus japonicus.—Bigelow, 1931, p. 145, pl. 1 (fig. 1).—Edmondson, 1946, p. 243. [Not *O. japonicus* (de Haan, 1844).]

HOLOTYPE.—1 ♂, 107.0; off coast of Maui Is., Hawaiian IIs.; 173–276 m; *Albatross* Sta. 4098; July 23, 1902; USNM 64861.

PARATYPE.—1 ♀, 29.4; off south coast of Molokai Is., Hawaiian IIs.; 109–116 m; *Albatross* Sta. 3845; Apr. 8, 1902; USNM 64863.

OTHER MATERIAL.—1 ♂, 32.2; off northeast coast of Hawaii Is., Hawaiian IIs.; 151–206 m; *Albatross* Sta. 4062; July 18, 1902; USNM 64862.

DESCRIPTION.—Eye large, cornea longer than broad, set obliquely on short stalk; ocular scales oblique, appressed along midline; eyes not extending to end of second segment of antennular peduncle.

Antennular peduncle short, about two-thirds as long as carapace.

Antennal scale broad, ovate, completely setose, anterior setae smaller than posterior; scale five-sixths length of carapace.

Rostral plate short, triangular, with acute, deflexed apex; plate anteriorly sulcate along midline; apex of plate extending to posterior margin of ocular scales.

Dactylus of raptorial claw with 7–8 teeth.

Abdomen smooth, second to fifth somites with anterolateral pit and shallow groove posterior to each pit, grooves increasing in size posteriorly; groove of fifth somite with prominent, almost carinate margins; fourth and fifth somites each with posterolateral spinules; sixth somite with faintly indicated lobe in front of articulation of uropod; sixth somite with 3 pairs of primary carinae, submedians, intermediates, and laterals armed with at most apical tubercles in holotype; submedians each with posteriorly reflected carina, not extending to posterior margin; broad tubercle present on each side between intermediate and lateral carinae.

Telson broader than long, with full complement of carinae; 2 pairs of accessory medians present, outer irregular; submedians faintly suppressed at base of marginal teeth, extending almost to anterior margin of telson; submedian tooth and first intermediate denticle with short dorsal carina, carina of denticle not extending anteriorly past base of denticle; short intermediate, lateral, and marginal carinae present, laterals extending obliquely to apex of tooth; low anterior swellings present lateral to outer accessory median and submedian carinae.

Outer margin of proximal segment of uropodal exopod with 11–12 broad, tapering, upturned spines, last extending to or beyond mid-length of distal segment; distal segment of uropod more than half as long as proximal.

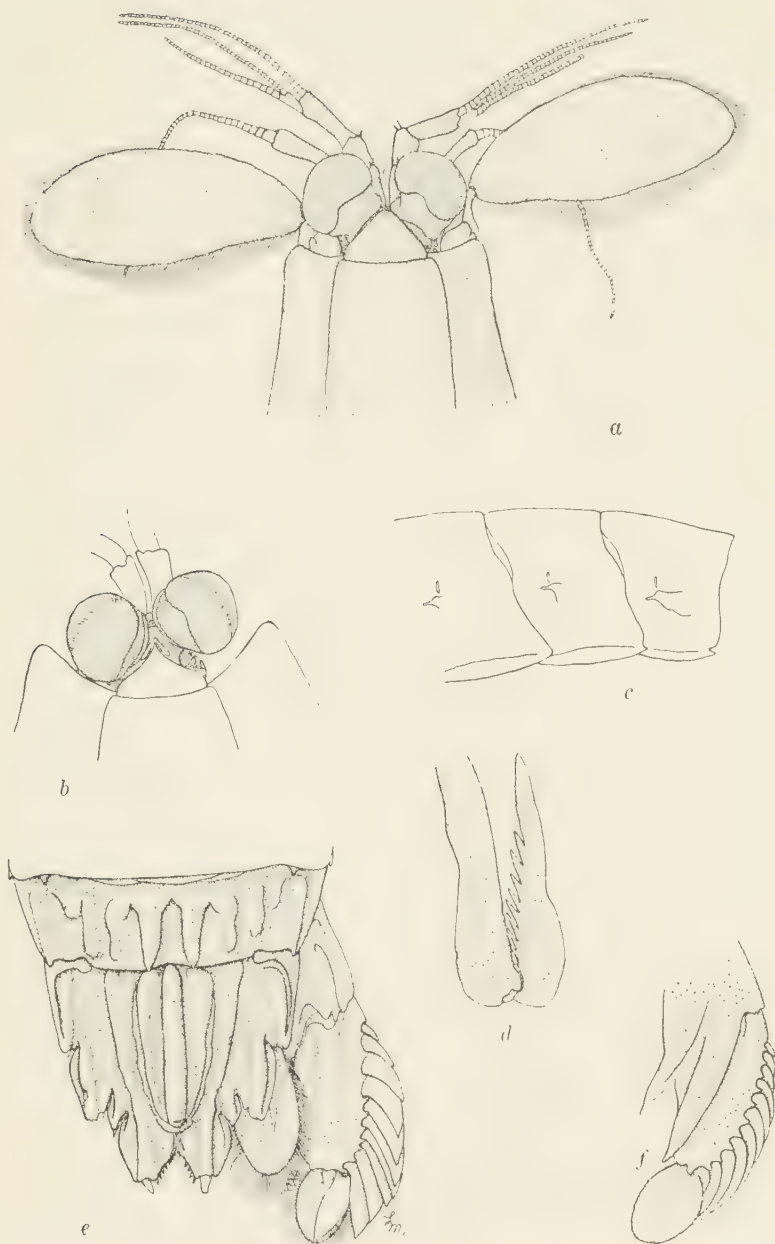


FIGURE 4.—*Odontodactylus hawaiiensis*, new species, male holotype, TL 107.0 mm, Hawaii: *a*, anterior portion of body; *b*, oblique frontal view of carapace and ocular scales; *c*, third to fifth abdominal somites in lateral view; *d*, propodus and dactylus of raptorial claw; *e*, sixth abdominal somite, telson, and uropod; *f*, uropod, ventral view (setae omitted).

COLOR.—Almost completely faded in all specimens. The smaller male has traces of a black spot on the uropodal exopod similar to that found in *O. brevirostris*.

SIZE.—Males, TL 32.2–107.0 mm; only known female, TL 29.4 mm.

Measurements and indices for selected specimens of *O. hawaiiensis*, new species, are as follows:

	♀	♂	♂
Total length	29.4	32.3	107.0
Carapace length	6.3	7.5	24.0
Cornea length	—	—	6.0
Cornea width	2.0	—	5.6
Antennal scale length	—	—	20.8
Fifth abdominal somite width	6.2	7.0	22.7
Telson length	4.0	4.6	16.5
Telson width	5.0	5.9	19.2
CI	315	—	429
AWCLI	1016	933	945
Uropod P/D	1.48	1.55	1.60

DISCUSSION.—*O. hawaiiensis* most closely resembles *O. japonicus* (de Haan) and was identified with that species by Bigelow (1931). It differs from *O. japonicus* as follows: (1) the apex of the rostral plate is acute, sharp, not truncate; (2) the margin of the antennal scale is completely lined with setae; (3) the fourth and fifth abdominal somites are armed posterolaterally; and (4) there is no carina on the telson extending anteriorly from the inner intermediate denticle. *O. hawaiiensis* also resembles *O. brevirostris* in general facies, but the latter species has a more rounded rostral plate in the adult, a deep pit between the ocular scales, and but one pair of accessory median carinae on the telson. *O. scyllarus* and *O. cultrifer* both differ from *O. hawaiiensis* in having less than 5 teeth on the dactylus of the raptorial claw.

Small specimens of *O. hawaiiensis* may have an anterior groove in the rostral plate, as in *O. brevirostris*, but even the smallest specimen can be distinguished by the position of the ocular scales.

DISTRIBUTION.—Known only from off Hawaii, in depths between 109 and 276 m.

Odontodactylus cultrifer (White, 1850)

FIGURE 5

Gonodactylus cultrifer White, 1850, p. 96, pl. 16 (figs. 1–2); 1851, p. 422.—Miers, 1880, p. 117.—Lanchester, 1901, p. 555.

Gonodactylus carinifer Pocock, 1893, p. 478, pl. 20B (figs. 4a–b).

Odontodactylus carinifer.—Bigelow, 1894, p. 496 [key].—Kemp, 1913, p. 138.—Gravier, 1933, p. 78, figs. 3–5.—Serène, 1937, p. 68 [listed].—Dawydoff, 1952, p. 145 [discussion].—Serène, 1953, p. 506.

Odontodactylus cultrifer.—Bigelow, 1894, p. 496 [key].—Kemp, 1913, p. 137.—Sunier, 1918, p. 11.—Kemp and Chopra, 1921, pp. 297 [listed], 307.—Odhner, 1923, p. 7.—Hansen, 1926, p. 23 [discussion].—Stephenson, 1952, p. 10;



Odontodactylus hawaiiensis, new species, male holotype, TL 107.00 mm, Hawaii: Specimen in dorsal view (from Bigelow, 1931).

1953, p. 46.—Serène, 1953, p. 506; 1954, pp. 6, 8, 11, 13, 17, 72, pl. 6 (figs. 5-6).—Stephenson and McNeill, 1955, p. 248.—Stephenson, 1962, p. 35.—Serène, 1962, fig. 1E2.—Manning, 1966, p. 105.

Odontodactylus cultifer.—Schmitt, 1929, p. 147 [listed].

Odontodactylus mindanaoensis Roxas and Estampador, 1930, p. 115, pl. iv.

Odontodactylus cultrifer var. *tridentata* Serène, 1954, pp. 6, 7, 8, 72, pl. 6 (figs. 7-8).

MATERIAL.—1 broken ♂, 125.4; 10 mi. northwest of Bustard Head, off Port Curtis, Queensland, Australia; 29 m; *Endeavour*; AM E.3154.—1 broken ♀, 106.5; Platypus Bay, Queensland; 13-16 m; *Endeavour*; USNM 111380.—1♀, 118.2; same; *Endeavour*, no. 1, haul 2; July 28, 1910; AM P.3549.—1 broken ♂; 2♀, 92.0-93.5; ca. 5 mi. east northeast of Scarborough edge of northern Banks, Moreton Bay, Queensland; 9 m; Mar. 29, 1966; W. Stephenson, M. Rees; USNM 120266.—2 ♂, 101.4-118.7; 1♀, 86.7; Eastern Banks, northern Moreton Bay, Queensland; ca. 9 m; Mar. 29, 1966; W. Stephenson, M. Rees; USNM 120267.—1 ♂, 28.0; Holothuria Bank; 44 m; holotype of *Gonodactylus carinifer* Pocock; BMNH 92.3.26.460.—1 ♂, 93.7; off Frederick Hendrik Is., New Guinea; Feb. 10, 1955; D. C. Lwolla; RMNH 354.—1 ♂, 67.2; Maculabo Is., Philippine Is.; June 13, 1909; *Albatross*; USNM 76024.—1♀, ca. 70.0; Malatrujo Point, Batanjas, Philippine Is.; 1938; AMNH 8253.—2♀, 57.3-66.5; Poulo Condore Is., off Viet Nam; March 1931; Dawydoff; MNHNP.—2 dry ♂, CL 20.4, 20.5; China; Dr. Cuming; syntypes; BMNH 49.55.—2 dry ♂ (in 2 lots), each 110.0; China; S. Heymann; UZM.

DESCRIPTION.—Eyes subglobular, cornea length greater than width; eyes extending to or beyond end of second segment of antennular peduncle; anterior margin of ophthalmic somite truncate, projecting slightly; ocular scales rounded, widely separate, lacking prominent pit between them on midline.

Antennular peduncle about two-thirds carapace length.

Antennal scale large, ovate, about as long as carapace; margin completely setose, anterior setae smaller than posterior; dorsal plate of antennal peduncle rounded.

Rostral plate trapezoidal, anterior margin deflexed, transverse, with faint median sulcus; lateral margins concave.

Carapace narrowed anteriorly, anterior margin evenly curved, concave anteriorly; posterior margin concave medially.

Raptorial claw small, dactylus armed with 3-5 teeth; basal, swollen portion of dactylus rounded; ischium with prominent ventral keel, projecting anteriorly.

Fifth thoracic somite without definite lateral process; lateral process of sixth thoracic somite truncate, that of seventh somite rounded, neither with prominent posterior lobe; ventral keel on eighth somite low, inconspicuous.

First 5 abdominal somites lacking carinae, second to fifth somites each with anterolateral pit; fifth somite with minute posterolateral spine, situated anterior to posterolateral angle; sixth somite with 3

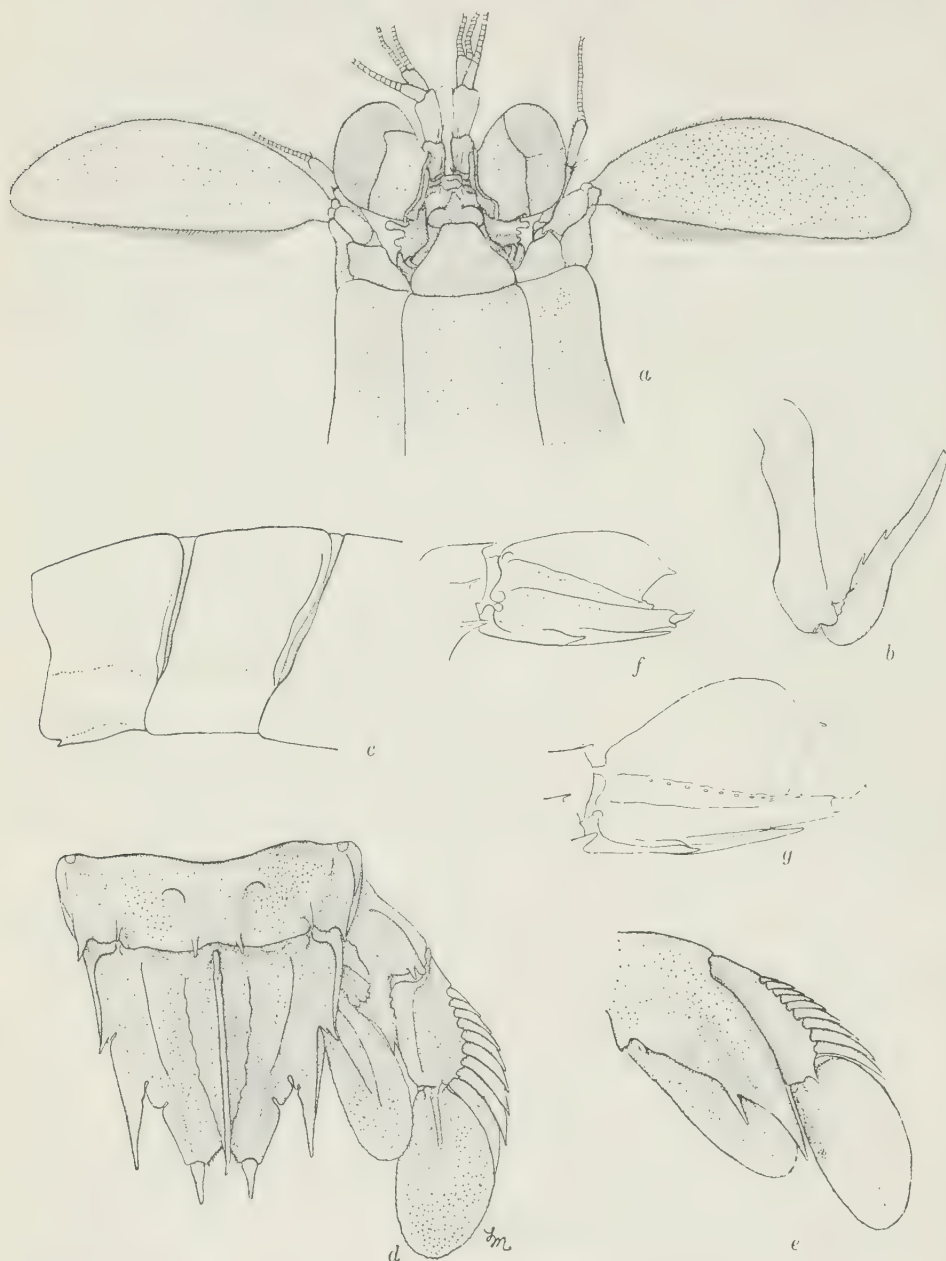


FIGURE 5.—*Odontodactylus cultrifer* (White). Male TL 67.2 mm, Philippine Islands: *a*, anterior portion of body; *b*, propodus and dactylus of raptorial claw; *c*, third to fifth abdominal somites, in lateral view; *d*, sixth abdominal somite, telson, and uropod; *e*, uropod, ventral view (setae omitted in *d*, *e*). Female, TL 106.5 mm, Platypus Bay: *f*, telson in lateral view. Male, TL 125.4 mm, off Port Curtis: *g*, telson in lateral view.

pairs of carinae terminating in spines, posteriorly recurved portion of submedians absent; anterior tubercle present between intermediate and lateral carinae; sixth somite without ventrolateral spine in front of articulation of uropod, ventral posterior margin almost transverse, not strongly concave.

Telson slightly broader than long, appearing elongate; median carina thin, strongly convex, high, about one-fourth telson width in female, almost one-half telson width in males, with strong posterior spine; dorsal surface of telson, lateral to crest, ornamented with (1) a single accessory median carina, (2) a long, uninterrupted submedian carina, (3) a short carina on intermediate tooth, and (4) a lateral carina subparallel to and separated from marginal carina by a narrow space, 2 small swollen, tubercles situated lateral to termination of each submedian carina.

Uropod broad, dorsal spine of basal segment very small; distal segment of exopod longer than proximal; 8-9 movable spines on outer margin of proximal exopod segment, last not extending to midlength of distal segment; endopod ovate, with 2 swollen, short, longitudinal carinae.

COLOR.—Faded in most specimens. Relatively fresh specimens show traces of dark chromatophores scattered over the body, but concentrated in an oblique line on the first abdominal somite just behind the articulated plates and on the telson at the base of the median carina; some specimens have pairs of submedian pink spots on the last three thoracic and first five abdominal somites; the distal portion of the antennal scales and tips of the uropod are pink. Komai (1927, 1938) and Stephenson (1952) have also given notes on color.

MEASUREMENTS.—Males, TL 28.0-125.4 mm; females, TL 57.3-118.2 mm.

Measurements and indices for selected specimens of *O. cultrifer* (White) are as follows:

	♀	♀	♂	♀	♂	♀	♂
Total length	57.3	66.5	67.2	70.0	93.7	106.5	125.4
Carapace length	11.1	13.1	13.2	13.5	18.2	19.6	23.5
Cornea length	3.6	4.1	4.6	4.7	5.0	6.0	5.6
Cornea width	3.9	4.2	4.1	4.5	5.0	6.4	6.1
Antennal scale length	10.8	13.0	13.1	—	—	—	26.9
Fifth abdominal somite width	12.2	14.4	13.7	15.0	19.1	20.6	24.5
Telson length	9.1	10.6	10.2	11.4	14.7	16.2	20.0
Telson width	10.9	11.5	11.0	12.3	15.4	16.8	20.0
CI	285	312	322	300	364	306	385
AWCLI	1099	1099	1037	1111	1049	1051	1042
Uropod P/D	0.879	0.900	0.640	0.929	—	0.814	0.775
Telson W/Crest Ht	220	329	367	362	230	381	235

DISCUSSION.—The most distinctive feature of *O. cultrifer* is the relative size of the segments of the uropodal exopod; in no other species of the genus is the distal segment longer than the proximal.

The median carina of the telson is characteristically slender and highly arched dorsally, and it is much higher in mature males than in mature females. In females the telson width/median carina height ratio ranges from 3.29 to 4.55, in males from 2.17 to 3.67.

Pocock (1893) was the first to suggest that his *O. carinifer* might be the young stage of *O. cultrifer*, and Hansen (1926) synonymized the former with the latter. After examining the type of *O. carinifer*, I must agree with Hansen. In 1966 I pointed out that *O. mindanaoensis* Roxas and Estampador should be referred to *O. cultrifer*. The type of *O. mindanaoensis* is a small female with a low median carina on the telson; the description and figures agree with *O. cultrifer* in all respects but one: the distal segment of the uropodal exopod is shorter than the proximal. The illustration is highly stylized so the size of the two segments may not have been drawn correctly.

O. cultrifer var. *tridentata* Serène, 1954, was also provisionally synonymized with *O. cultrifer* by me in 1966. I can find no characters to distinguish the varietal form from *O. cultrifer* sensu stricto; the variety seems to have been recognized on the basis of a larger number of teeth on the claw and a relatively lower median carina on the telson. In my material the height of the median carina varies somewhat and there may be three, four, or five teeth on the dactylus of the claw.

DISTRIBUTION.—Western Pacific Ocean, from Australia and New Guinea northward to Japan, in shallow water.

***Odonodactylus brevirostris* (Miers, 1884)**

FIGURES 6-8

Gonodactylus brevirostris Miers, 1884, p. 567, pl. 52 (fig. c)[*Gonodactylus elegans* in legend].

Gonodactylus Havanensis Bigelow, 1893, p. 101 [June].

Gonodactylus Hansenii Pocock, 1893, p. 477, pl. 20B (figs. 3-3b)[June].

Odontodactylus brevirostris.—Bigelow, 1894, p. 496 [key].—Tattersall, 1906, p. 172, pl. 2 (figs. 16-18).—Borradaile, 1907, p. 212.—Kemp, 1913, p. 143.—Kemp and Chopra, 1921, p. 297 [listed].—Komai, 1938, p. 272, fig. 2.—Edmondson, 1946, p. 243.—Manning, 1967, in press [summary of Atlantic records].

Odontodactylus havanensis.—Bigelow, 1894, p. 497, text-figs. 1-2, pl. 20.—Kemp, 1913, p. 204 [listed].

Odontodactylus hansenii.—Bigelow, 1894, p. 496 [key].—Kemp, 1913, p. 140.—Dawydoff, 1952, p. 146 [*G. hansenii* on p. 145].—Townsend, 1953, p. 421, figs. 18-19.

Odontodactylus latirostris Borradaile, 1907, p. 212, pl. 22 (figs. 3, 3a).—Kemp, 1913, p. 141.

Odontodactylus southwelli Kemp, 1911, p. 94; 1913, p. 142, pl. 9 (figs. 103-106).—Kemp and Chopra, 1921, p. 297 [listed].

Odontodactylus hansenii.—Edmondson, 1921, p. 297, fig. 1f.—Bigelow, 1931, p. 147, fig. 2.—Edmondson, 1946, p. 243.

Odontodactylus hansenii.—Hansen, 1926, pp. 23, 44 [larvae], pl. 2 (figs. 7-9).

?*Odontodactylus japonicus*.—Komai, 1927, p. 336 [part].

Odontodactylus nigricaudatus Chace, 1942, p. 88, pl. 28; 1954, p. 449.

MATERIAL.—2♀, 17.2-53.4; Amirante IIs.; 46-146 m; J. S. Gardiner, M. A. Caius; syntypes of *O. latirostris*; UMZ.—1♀, 26.2; Seychelles; 62 m; Oct. 20, 1905; J. S. Gardiner, M. A. Caius; UMZ.—1♂, 23.3; Providence Is., south of the Seychelles IIs.; *Alert*, col., holotype of *G. brevisrostris*; BMNH 82.27.—1♀, 55.2; east of Lowi and Lowalafuri IIs., south entrance to Fadifolla Atoll, Maldive IIs.; 05°20' N, 73°29' E; 46-64 m; *Te Vega* Sta. 122 A+B; Mar. 25, 1964; J. S. Garth; USNM 120260.—1♀, 13.8; Oyster Banks, Manaar, Ceylon; Herdman Collection; BMNH 10.27.5.—1♀, ca. 13.7; no local; 10 m to surface; *Siboga*; Apr. 3, 1900; ZMA.—1♀, 30.5; Anchorage east of Dangar Basin, Saleh-bay, Sumbawa, Indonesia; 36 m; *Siboga* Sta. 313; Feb. 14-16, 1900; ZMA.—1♂, 13.0; Mamoeedjoe, west coast of Celebes; *Snellius* Exped.; Aug. 5, 1929; RMNH 288.—1♂, 25.4; Lembeh Strait, Celebes; June 14, 1929; Herre; USNM 120261.—1♂, 25.5; Banda anchorage; *Siboga* Sta. 240; Nov. 22-Dec. 1, 1899; ZMA.—1♀, 36.6; Amboina Bight, Indonesia; 91 m; Mar. 3, 1922; Danish Expedition to Kei-Qeme, 1922; UMZ.—1♀, 59.0; off northwest New Guinea; 00°07.2' N, 130°25.5' E; 83-59 m; *Siboga* Sta. 154; Aug. 14, 1899; ZMA.—1♂, 16.0; off northwest New Guinea; 01°42.5' S, 130°47.5' E; 32 m; *Siboga* Sta. 164; August 1899; ZMA.—1♂, 16.1; North-Ubian, Philippine IIs.; 06°07.5' N, 120°26' E; surface; *Siboga* Sta. 99; June 28-30, 1899; ZMA.—1 broken ♂, CL 13.7; Jolo, Philippine IIs.; 46 m; Mar. 19, 1914; Th. Mortensen; UMZ.—1 broken ♀, ca. 61.5; Macclesfield Bank, South China Sea; holotype of *Gonodactylus hansenii*; BMNH 92.8.28.13.—1♂, 26.5; Waikiki, Oahu, Hawaiian IIs.; 1921; D. Kuhns; USNM 56048.—1♀, 32.7; Hawaii; 1916; Tha'anum, col.; UZM.—1♂, 50.4; southern coast of Molokai Is., Hawaiian IIs.; 109-116 m; *Albatross* Sta. 3845; Apr. 8, 1902.—1♀, 26.7; Pailolo Channel, between Molokai and Maui IIs. and north-eastern approach, Hawaiian IIs.; 55-95 m; *Albatross* Sta. 3861; Apr. 10, 1902; USNM 64869.—1♂, 56.9; off Kauai Is., Hawaiian IIs.; 424-73 m; *Albatross* Sta. 3982; June 10, 1902; USNM 64865.—1♀, 79.4; Penguin Bank, southern coast of Oahu Is., Hawaiian IIs.; 49-51 m; *Albatross* Sta. 4031; July 9, 1902; USNM 64864.—1♀, 26.9; same; 51-25 m; *Albatross* Sta. 4034; July 9, 1902; USNM 64868.—1♂, 31.7; northeastern coast of Hawaii Is., Hawaiian IIs.; 44-151 m; *Albatross* Sta. 4061; USNM 64867.

DESCRIPTION.—Eye large, cornea subglobular, set obliquely on short stalk; eyes extending to or slightly beyond end of second segment of antennular peduncle; ocular scales oblique to body line, separate,

connected by median, concave ridge defining a deep pit between the scales.

Antennular peduncle short, about five-sixths as long as carapace. Antennal scales elongate, slightly shorter than median length of

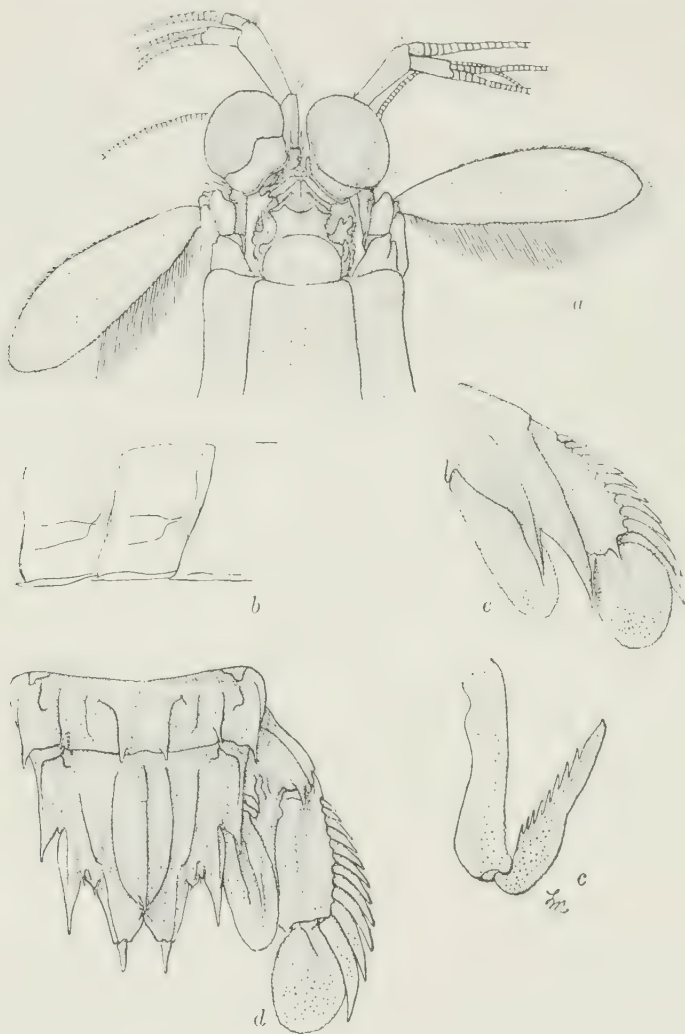


FIGURE 6.—*Odontodactylus brevirostris* (Miers), male, TL 56.9 mm, Hawaii: *a*, anterior portion of body; *b*, third to fifth abdominal somites, in lateral view; *c*, propodus and dactylus of raptorial claw; *d*, sixth abdominal somite, telson, and uropod; *e*, uropod, ventral view (setae omitted in *d*, *e*).

carapace; margin almost completely setose, proximal fourth of anterior margin not setose, anterior setae much smaller than posterior.

Rostral plate short, evenly rounded; plate in juvenile specimens trapezoidal or rounded, apex slightly deflexed.

Dactylus of raptorial claw with 6–10 teeth.

Second to fifth abdominal somites each with anterolateral pit from which a shallow groove extends posteriorly; grooves increasing in depth posteriorly, on fourth somite flanked by low carina, flanking carina of fifth somite more prominent; sixth somite with 6 pairs of sharp posterior spines, submedians each with posteriorly reflected portion lying between submedian and intermediate carinae; sixth somite with large anterior tubercle between intermediate and lateral carinae; third to fifth abdominal somites with posterolateral spines; sixth somite without ventrolateral spines in front of articulation of uropod.

Telson broader than long, with 1 pair of accessory median carinae; submedians long, occasionally suppressed at base of submedian tooth; intermediate denticles with short dorsal carina; carina of intermediate tooth not extending anteriorly much past base of tooth; lateral carinae subparallel or convergent with marginal, if subparallel apex occasionally turning toward and fusing with apex of marginal carina on lateral tooth; anterior surface of telson with distinct tubercle lateral to submedian carina.

Outer margin of proximal segment of uropod exopod with 8–11 movable spines, not markedly spatulate or upturned, last not extending to end of distal segment; distal segment of uropod about four-fifths as long as proximal, relative lengths of the segments varying; outer spine of basal prolongation the longer.

COLOR.—Faded in most specimens except for a dark spot on the proximal segment of the uropodal exopod. One specimen had short, interrupted lines on the dorsum of the body and dark posterolateral patches on the carapace in addition to the spots on the uropods.

SIZE.—Males, TL 13.0–56.9 mm; females, 13.7–79.4 mm.

Measurements and indices for selected specimens of *O. brevirostris* (Miers) are as follows:

	FEMALES							
Total length	26.2	30.5	32.7	36.6	53.4	61.5	55.2	79.4
Carapace length	5.8	7.5	7.8	8.8	11.9	12.9	13.0	17.8
Cornea length	1.8	2.4	2.5	3.2	3.3	3.5	3.4	4.0
Cornea width	2.1	2.1	2.5	3.7	3.2	3.7	3.1	4.1
Antennal scale length	3.2	4.9	5.3	—	—	—	—	—
Fifth abdominal somite width	5.3	6.8	8.0	9.1	12.6	13.0	12.5	17.2
Telson length	4.7	3.9	5.1	5.6	8.4	9.8	8.9	12.7
Telson width	4.0	5.4	6.5	7.3	10.1	10.2	10.6	13.8
CI	276	357	312	238	372	349	419	434
AWCLI	913	906	1025	1034	1058	1007	961	966
Uropod P/D	2.00	1.14	1.52	1.61	1.02	1.68	1.25	—

	MALES				
Total length	25.5	25.4	31.7	50.4	56.9
Carapace length	5.2	5.5	6.8	10.9	11.7
Cornea length	2.0	2.3	2.5	3.5	3.8
Cornea width	1.8	1.9	2.4	4.0	4.5
Antennal scale length	4.0	—	4.8	—	10.6
Fifth abdominal somite width	5.3	5.5	6.5	10.9	11.8
Telson length	3.2	3.8	4.6	7.3	8.7
Telson width	4.4	4.5	5.5	8.5	9.2
CI	289	289	283	272	260
AWCLI	1019	1000	955	1000	1008
Uropod P/D	1.24	1.21	1.25	1.12	1.13

DISCUSSION.—The presence of ocular scales separated by a deep pit, more than five teeth on the raptorial claw, and only one pair of accessory median carinae on the telson will distinguish *O. brevirostris* from all other species in the genus. The ocular scales and characteristic intervening pit are visible even in first stage postlarvae.

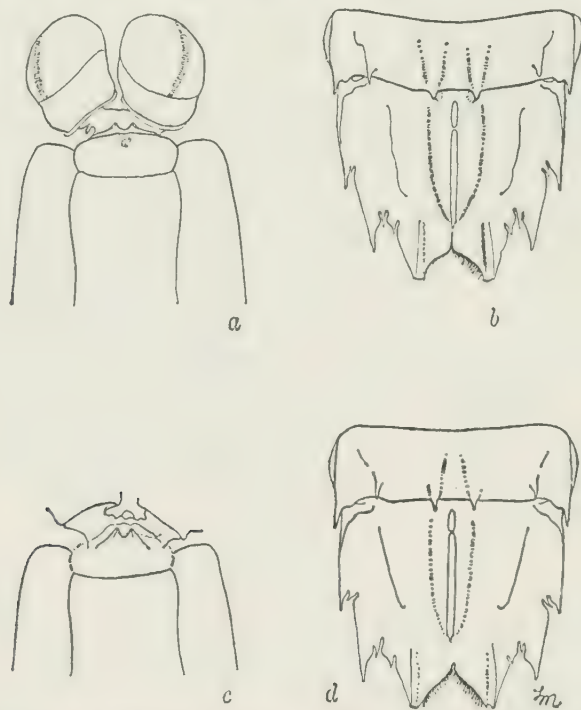


FIGURE 7.—*Odontodactylus brevirostris* (Miers). Female, TL 26.9 mm, Hawaii: *a*, outline of front; *b*, outline of sixth abdominal somite and telson. Male, TL 26.5 mm, Hawaii: *c*, outline of front to show ocular scales; *d*, outline of last abdominal somite and telson.

It is with some hesitation that I use the name "*brevirostris*" for this species. The type of *O. brevirostris* is a young male with only submedian carinae on the telson, but the ocular scales are clearly separated

by a pit and the claw has nine teeth. No differences could be found between it and specimens of similar size from the Indo-West Pacific. A western Atlantic specimen compared with the type is smaller but apparently identical.

O. brevirostris has a comparatively larger eye at any size than any other species of the genus. Kemp (1911, 1913) commented upon the large size of the eyes in his specimens of *O. southwelli*.

Juveniles of *O. brevirostris*, TL 13–30 mm (fig. 7), may not have the full complement of carinae on the last abdominal somite and telson. The carinae may be present in specimens as small as TL 16–20 mm (fig. 8) and absent in specimens as large as TL 27 mm.

Five specimens of large postlarvae have been examined. Data on postlarvae and juveniles are summarized as follows:

1. Small postlarvae (telson with median and submedian carinae only):

TL 13.0 mm	Bahamas	USNM	♀ ?
TL 13.0 mm	Celebes	RMNH	♂
TL 13.7	[Indo-Malaya]	ZMA	♀ ?
TL 13.8	Ceylon	BMNH	♀ ?

2. Large postlarvae (as above but of larger size):

TL 23.3	Providence Is.	type of <i>G. brevirostris</i>	♂
TL 26.2	Seychelles	UMZ	♀ ?
TL 26.5	Hawaii	USNM	♂
TL 26.7	Hawaii	USNM	♀ ?
TL 26.9	Hawaii	USNM	♀ ?

3. Juveniles (telson with full complement of carinae):

TL 16.0	New Guinea	ZMA	♂
TL 16.1	Philippines	ZMA	♂
TL 17.2	Amirantes Is.	syntype of <i>O. latirostris</i>	♀ ?
TL 20.0	Cuba	type of <i>G. havanensis</i>	♂
TL 25.4	Celebes	USNM	♂
TL 25.5	Banda	ZMA	♂

All larger specimens have the telson provided with the normal complement of carinae.

The small and large postlarvae appear to be identical except for size. All large postlarvae are from Indo-West Pacific whereas small postlarvae and small juveniles may occur in both the Atlantic and the Indo-West Pacific.

There are several possible explanations for the differences in size of the postlarvae. The term "postlarva" is used for young specimens at the first intermolt state after the last pelagic larval stage. In *Alima hyalina* (see Manning, 1962) the postlarva is a distinct, benthic stage intermediate between the last larva and the first-stage juvenile. *Alima* has but one postlarval stage; with the next molt it assumes features that are more characteristic of the adult. In *Odontodactylus*

there may be more than one postlarval stage during which the animal increases in size but does not develop the characteristic telson morphology of the adult, although this seems unlikely. In *Alima hyalina* the last larval stage is almost twice as long as the postlarva; *Odontodactylus* may have a larger postlarva than juvenile. Under certain conditions *Odontodactylus* may also have some mechanism of prolonging the larval stage so that postlarvae may be of different size. Finally,

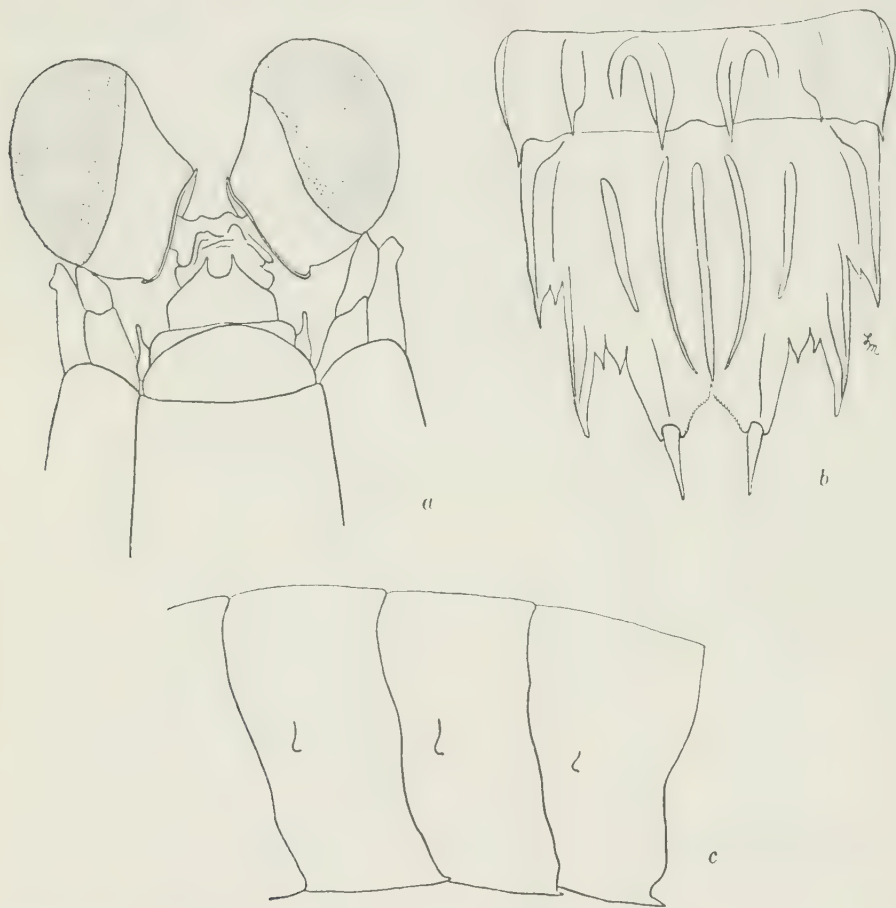


FIGURE 8.—*Odontodactylus brevirostris* (Miers), holotype of *Gonodactylus havanensis* Bigelow, male, TL 20.0 mm, off Havana: *a*, front; *b*, sixth abdominal somite and telson; *c*, third to fifth abdominal somites in lateral view.

there may be more than one species involved and two or more species may be represented in the available material. Until more is known about the ontogenetic changes in *Odontodactylus*, the specimens of that genus, with the widely separate ocular scales, more than five teeth on the claw, and one pair of accessory median carinae on the telson, should be referred to *O. brevirostris*.

A similar disparity of size in postlarvae has been observed in young specimens of *O. scyllarus*.

Juveniles of *O. brevirostris* may also differ from adults in having the rostral plate trapezoidal in shape rather than semicircular; however, the latter shape is more usual.

I have been unable to detect any differences between adult specimens (TL 40 mm or more) from the western Atlantic and the Indo-West Pacific. The type of *Gonodactylus havanensis*, a male, TL 20.0 mm, is illustrated in outline in figure 8. As in most small specimens of similar size from the Indo-West Pacific, the carinae of the telson are relatively well developed. The western Atlantic *O. nigricaudatus* cannot be distinguished from specimens of similar size from the Indo-West Pacific, and it, too, must be considered a synonym of *O. brevirostris*. A more detailed account of the western Atlantic specimens is in press.

In *O. brevirostris* the carina of the lateral tooth may lie parallel with the margin, it may converge distally with the marginal carina, or it may lie parallel except for its extremity, which turns and fuses with the marginal carina. The position of the carina is very variable, as noted by Bigelow (1931) in specimens from Hawaii.

DISTRIBUTION.—Western Atlantic and Indo-West Pacific, from the western Indian Ocean through Indo-Malaya to Hawaii; in moderate depth, to 424 m. This species lives at greater depths than any other in the genus.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3607

The Role of the Depressor Mandibulae Muscle in Kinesis of the Avian Skull

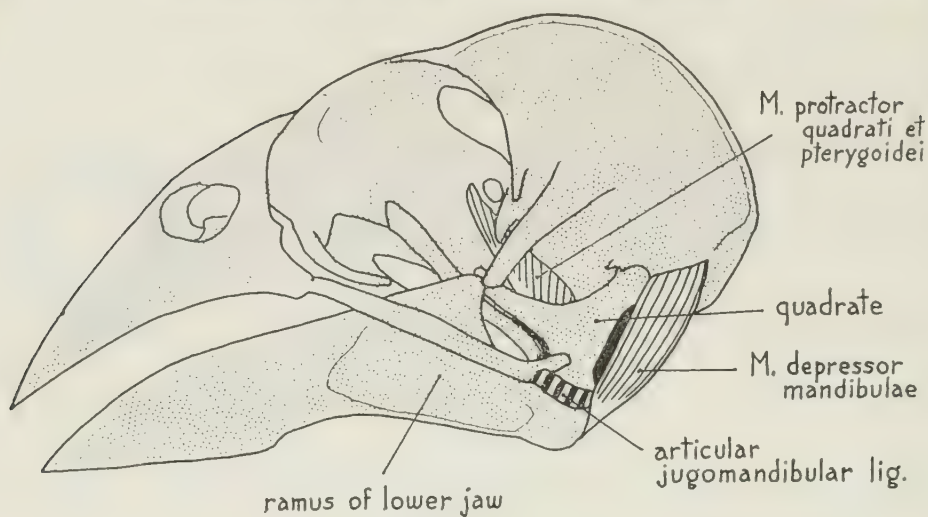
By Richard Zusi

Associate Curator, Division of Birds

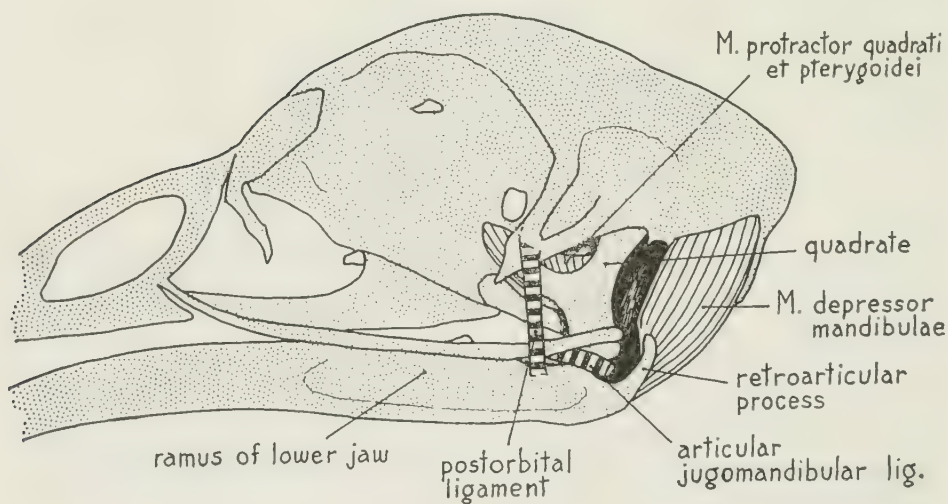
Introduction

Basic structures of the facial and palatal portions of the bird's skull are understandable only in terms of the kinetic property of the skull—the ability to move the upper jaw with respect to the braincase. Although avian kinesis was known to 18th-century anatomists and has been analyzed variously in terms of muscles, ligaments, and adaptive modifications, the important complex of structures constituting the jaw-quadrates linkage has not been studied sufficiently in any species to permit a detailed evaluation of the actions of the major jaw muscles.

My purpose here is to examine a single muscle, *M. depressor mandibulae*, to determine the effects upon jaw action of variations in muscle configuration and variations in the jaw articulation through which the muscle acts. (See fig. 1 for structures under discussion in this paper.) My methods include experiments based on stimulation of muscles in live birds, construction of models of the muscle-ligament system, and manipulation of fresh and preserved specimens. The



Hesperiphona vespertina



Gallus domesticus

FIGURE 1.—Structural features of the head in the evening grosbeak (*Hesperiphona vespertina*) and domestic chicken (*Gallus domesticus*). (Adductor and retractor muscle groups removed.)

most commonly stated action of *M. depressor mandibulae* is to open the lower jaw, but emphasis herein will be placed on the interaction between the postorbital ligament and the depressor mandibulae in protraction (raising) of the upper jaw. Several authors have postulated such a protraction effect through the postorbital ligament (Kripp, 1933, pp. 556–559; Starck, 1940, pp. 618–620; Barnikol, 1952, pp. 382–384; Zusi, 1962, p. 47; Bock, 1964, pp. 19–22), explaining its action, with some variations, as follows: the ligament is a virtually unstretchable band running from the cranium to the mandible and attaching anterior to the quadrate articulation, where the ligament provides a fulcrum around which the lower jaw pivots (see fig. 2). The depressor mandibulae rotates that portion of the lower jaw lying

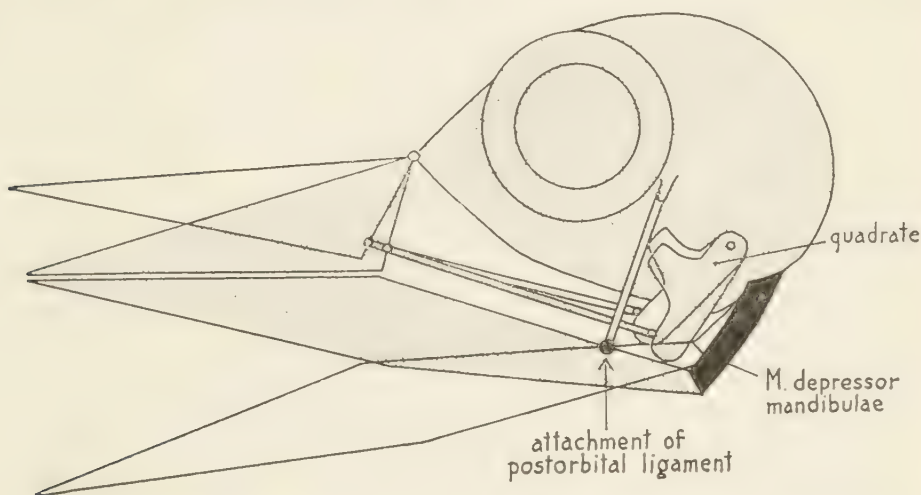


FIGURE 2.—Diagram of protraction of the upper jaw through the depressor mandibulae and postorbital ligament. The lower jaw pivots about the attachment of the ligament. As the lower jaw opens, the quadrate is pushed forward and the upper jaw is raised.

behind the attachment upward and forward, rocking the quadrates forward and thereby protracting the upper jaw. The important point is that the lower jaw pivots about the ligamentary attachment rather than about the quadrate articulation as is commonly stated. Bock (1964) has explored the significance of the postorbital ligament and has presented a number of hypotheses about avian kinesis that will be discussed below.

The group of structures that support the lower jaw form a closely interacting functional complex that is part of the larger complex of the entire kinetic mechanism. The support system includes the quadrate, the rami of the lower jaw, the jaw-quadrates articulation, and the muscles and ligaments associated with these structures. Most of the jaw muscles have the potential for moving the quadrate either through

direct attachment or indirectly by spanning its cranial and mandibular articulations. Motion of the quadrates has a direct effect on motion of the upper jaw and on the lower jaw as well; motion of the lower jaw may in turn induce shifting of the quadrates through features of the jaw articulation and ligaments. Understanding the functional properties of the complex kinetic mechanism is thus very difficult, but it is essential for the interpretation of variation of these structures in birds.

The depressor mandibulae has considerable potential for evolutionary development of functional-anatomical variation. Because of its superficial position, its origin may expand posteriorly over the neck muscles or dorsally and anteriorly over the skull and adductor muscles providing variation in both size and angle of pull of the muscle in different birds. The muscle may play a role in protraction of the upper jaw as well as in depression of the lower jaw, and therefore, it might be expected to show modifications for feeding methods that require forceful opening of both jaws or the upper jaw alone, or for resisting forces on the bill.

During the spring of 1963, Ulrich Kalkofen, then a senior honors student under my supervision at the University of Maine, undertook a series of pilot experiments to test hypotheses about the role of the postorbital ligament in kinesis (Kalkofen, 1963). The data obtained form the basis for the following section on jaw action. I wish to thank Paul C. Harris for providing the chickens used for this study and Jon Greenlaw for his help in performing the experiments. Financial assistance was provided by the Coe Research Fund (R 625-49) of the University of Maine. The final organization of the paper benefited greatly from the constructive criticisms of George E. Watson and Paul Slud. I am indebted to Walter J. Bock for providing me with a translation of the 1958 paper by Yudin.

Experiments on Jaw Action

METHODS.—Live birds used for experiment were the evening grosbeak (*Hesperiphona vespertina*) and the domestic chicken (*Gallus domesticus*)—hens of parentage female barred Plymouth Rock $\times$ male Rhode Island red. These species were especially suitable because they were readily obtainable and easily kept in captivity, and because the postorbital ligament is poorly developed in the grosbeak and strongly developed in the chicken.

For each species a wooden head support was constructed to conform with the contour of the mid-dorsal surface of the cranium; each support was held rigidly in place by metal clamps that penetrated under the supraorbital rims of the skull. Birds were first weighed

and then anaesthetized by intramuscular injection of equitheesin (0.20 ml. per 100 grams body weight, or more if necessary). Great care was taken to ensure that the birds were anaesthetized completely before and during the experimentation. Feathers of the head and neck were trimmed and the skin of both sides of the head reflected as soon as the bird lost consciousness. After the head support was fastened firmly to the bird, the support was held motionless by a vise and the body of the bird supported by the table or horizontally suspended in a plastic tube (fig. 3). The exposed jaw muscles were kept moist and clean throughout the experiments by periodic flushing with avian Ringer's solution at 38° C. The depressor mandibulae muscles were caused to contract simultaneously by a tetanizing

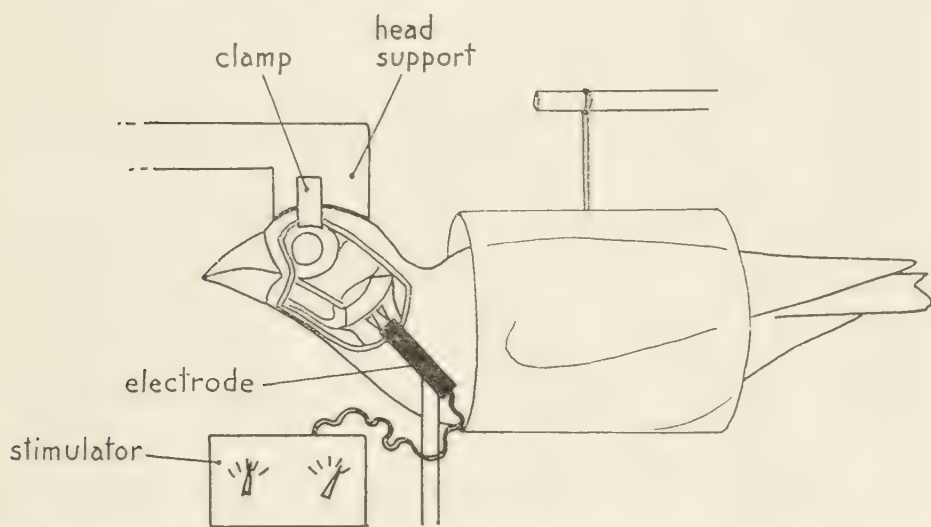


FIGURE 3.—Diagram of experimental setup for stimulating the depressor mandibulae muscles. The bill was photographed as viewed in the diagram before and during muscle stimulation.

stimulus of 20 volts (using two Harvard apparatus stimulators) applied through electrodes. The tips of both copper wires of each electrode were fitted with platinum wire bent as a triangle with one point of the triangle soldered to the wire and the opposite side of the triangle placed against the surface of the muscle. The bases of the two triangles of each electrode were parallel, about three mm apart, and were placed perpendicular to the long axis of the muscle. This type of contact gave consistent contractions, was easily applied and adjusted, and caused no damage to the muscles. Before stimulating the muscles simultaneously, each was individually stimulated to see that both were performing in a similar manner. Only at voltages exceeding 50 (and especially approaching 100) were there

spasmodic and unpredictable motions of the jaws caused by contractions of other muscles. Although 20 volts probably did not produce maximum contraction of the depressor mandibulae, it produced consistent jaw motions that could be safely attributed to contraction of the muscle under study.

The maximum number of consecutive stimulations, each of which lasted about two seconds, was 18 for a grosbeak and 17 for a chicken, during which the depressor muscles showed no signs of fatigue. Despite extensive severing of other jaw muscles the birds continued to respond well. All birds were killed while still under anaesthesia. The nature and extent of the operative procedures were then checked under a dissecting microscope immediately following each experimental series.

Just before stimulation of the muscles and again during stimulation and steady tetanic contraction, side view photographs of the jaws were taken. The two photographs from each experimental set were projected and traced, one superimposed on the other. I measured the motion of each jaw as degrees of arc between the resting position and the stabilized position during muscle contraction. The lower jaw has a longer radius of motion than the upper jaw because its fulcrum of rotation lies well behind that of the upper jaw. For this reason, the tip of the lower jaw travels farther than that of the upper jaw for the same number of degrees of movement. One therefore cannot obtain a meaningful measure of total gape simply by adding the degree motion of the two jaws, but differences within each jaw can be compared directly.

RESULTS.—Figure 4 presents the degree of motion of each jaw in bar graphs, whereas figure 5 shows several tracings of the jaws to give the reader a better impression of the actual amount of jaw motion. I must emphasize that throughout the experiments the depressors probably never were contracted maximally and the major protractor muscle of the upper jaw (protractor quadrati et pterygoidei) did not contribute to the observed jaw motion. As stated before, the evening grosbeak lacks a well-defined postorbital ligament, whereas the domestic chicken has a stout one.

It is clearly indicated in figure 4 that muscle contractions in the chicken produced repeatable results during experimentation with each bird (see A 1 and 2, 4 and 7; C 1 and 2; D 4 and 6, 7 and 9) and comparable results between different birds treated on different days (A 1, B 1, C 1, D 5).

The results of the experiments may be summarized as follows: (1) the depressor mandibulae caused protraction (raising) of the upper jaw and depression of the lower jaw in the domestic chicken and evening grosbeak; (2) the muscle caused opening of both jaws in the

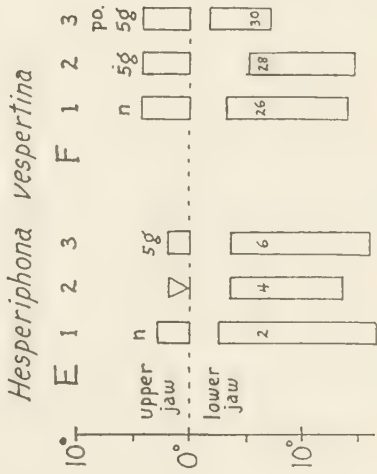
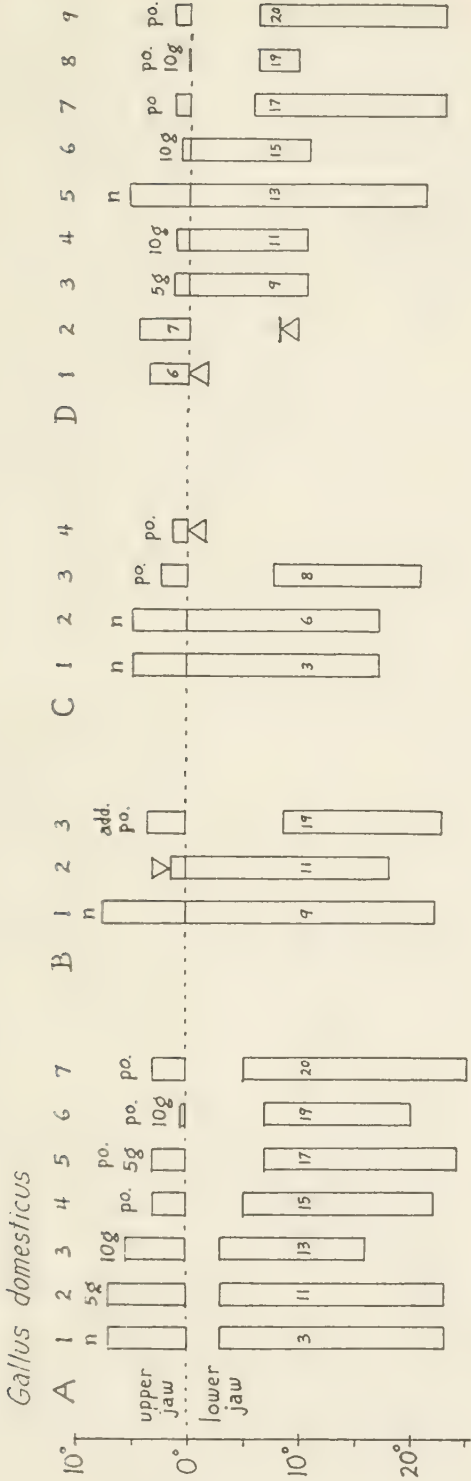


FIGURE 4.—Bar graphs of jaw motions during muscle experiments. Vertical axis equals degree of motion of each jaw measured above and below 0° (the closed position of both jaws). In each bar, the end closest to the 0° line shows the position of the jaw before contraction of the depressor mandibulae; the opposite end of each bar shows the position of the jaw during contraction. (A through F=different birds; numbers above bars=different experiments; number within a bar=consecutive position of that experiment in total experimental series; n=normal bird; 5g, 10g=gram weights suspended from culmen; po.=postorbital ligaments were cut; add. po.=all adductor muscles and postorbital ligaments were cut; $\triangle$ =restriction of jaw motion at apex of triangle.)

chicken after removal of the postorbital ligament; (3) protraction of the upper jaw by the depressor mandibulae was reduced after removal of the postorbital ligaments in the chicken; (4) depression of the lower jaw occurred when the upper jaw was held closed in both species; (5) protraction of the upper jaw occurred when the lower jaw was held closed in both species; and (6) the postorbital ligament played a role in holding the lower jaw partially closed at rest. In addition, protraction in the chicken following removal of the postorbital ligament was about half that of the normal condition. A weight of ten grams suspended from midway along the exposed culmen of the chicken reduced protraction in the normal bird and prevented protraction in birds from which the postorbital ligaments had been removed. Limiting or preventing motion of one jaw reduced but did not prevent motion of the other jaw. The postorbital ligament alone did not hold the lower jaw completely closed at rest (see fig. 4: A 1, 2, 3), but removal of the ligament shifted the jaw to a more depressed resting position. That the adductor muscles also played some role in support of the resting jaw is suggested by B 3, in which the jaw at rest was most strongly depressed following removal of both the postorbital ligaments and adductor muscles.

DISCUSSION.—The fact that the postorbital ligament and the depressor mandibulae can together produce protraction of the upper jaw is demonstrated by the experiments on domestic chickens described above. The ligament thus serves to coordinate motions of both jaws during depression of the lower jaw. Coordination of both jaws through the depressor mandibulae, however, does not require the presence of the postorbital ligament, and the ligament must be regarded as only one of several means (excluding other jaw muscles) of producing coordination. Furthermore, coordination of the jaws in the presence of a postorbital ligament is not obligatory; either jaw may also be moved independently.

Bock (1964) discussed the role of the postorbital ligament in avian kinesis, basing his conclusions on the results of manipulation of jaws in fresh birds and on inference from the anatomical structure of the jaw mechanism. His major hypotheses were as follows: (1) Two basically different kinetic mechanisms exist in birds—*coupled* and *uncoupled*. The jaws are coupled in those species with a postorbital ligament (or a functionally equivalent ligament), and/or with an interlocking arrangement of the jaw-quadrates articulation. Birds lacking both of these features have uncoupled jaws. (2) When the upper jaw of a coupled bird is held firmly in place, the lower jaw cannot be depressed. (3) In uncoupled birds the depressor mandibulae does not contribute to raising the upper jaw except perhaps when the mandible is depressed against resistance. (4) In coupled kinesis

it is impossible to depress the upper jaw beyond the closed position. (5) The elevated upper jaw cannot be lowered without raising the mandible. (6) Only those few groups of modern birds having uncoupled kinesis could have given rise to an akinetic form.

Although the experiments confirm the existence of coordinated jaw motion through the postorbital ligament, they nevertheless contradict

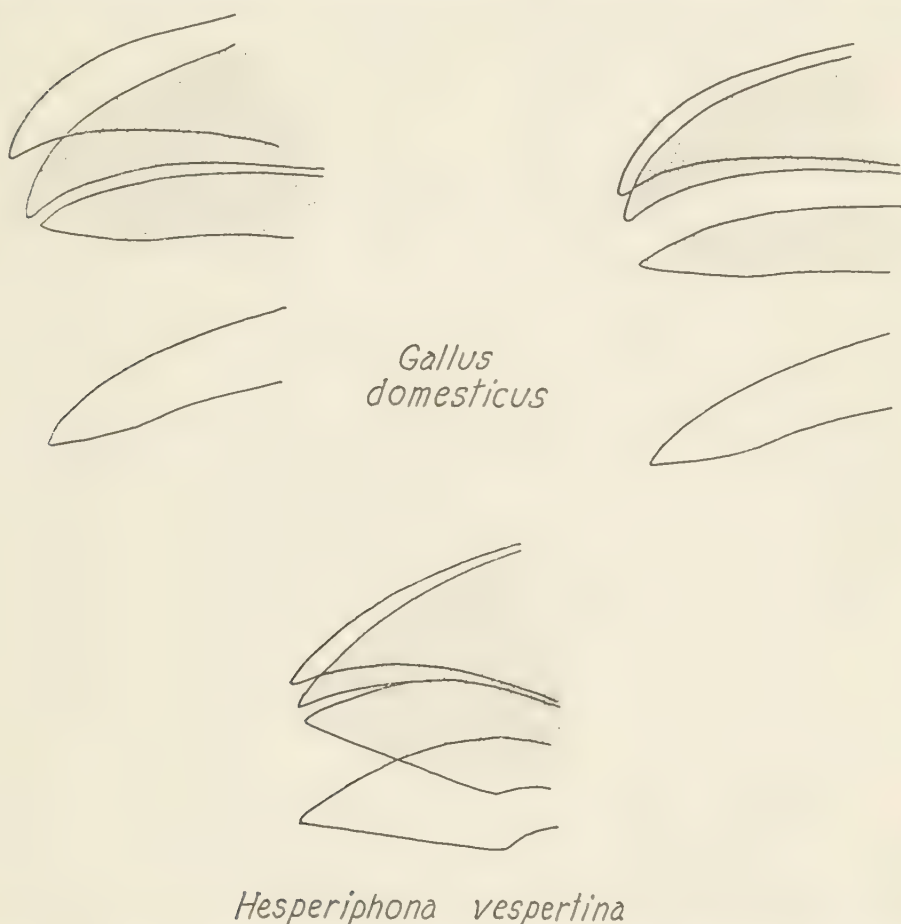


FIGURE 5.—Tracings of jaws from superimposed photographs taken before (stippled) and during contraction of the depressor mandibulae muscles. (Left: normal bird; middle: normal bird; right: postorbital ligaments cut. Drawings do not present maximum opening of either jaw.)

Bock's assumptions 1, 2, and 3 directly and 4, 5, and 6 by implication. The avian kinetic mechanism should not be regarded as either strictly coupled or uncoupled; rather, it is likely that many birds are coupled weakly, but probably few are coupled so strongly that other muscles cannot counteract the jaw linkage. Approaches toward complete coupling or complete independence of jaw action would represent

special adaptations rather than typical conditions. To better understand these complex kinetic relationships, three main questions must be answered: (1) How does the postorbital ligament produce coordination of the two jaws? (2) How can the jaws be alternately "coupled" and "uncoupled"? (3) What factors produce coordination in addition to or in the absence of the postorbital ligament? The first question is dealt with in the following section, and the second and third, under "Coordination and Independence of Jaw Action."

Angle of the Depressor Mandibulae

Zusi (1959) postulated that the depressor mandibulae could cause protraction of the upper jaw if part or all of the muscle pulled at an angle (forward and upward) with respect to the long axis of the quadrate. He stated that the forward component of force with respect to the quadrate would be transmitted to the quadrate through the lower jaw. Bock (1964, pp. 16, 17) disagreed, saying that the only point of relevance was whether or not the pull of the depressor had a component directed forward along the axis of the lower jaw, and he pointed out that such a forward component would diminish or disappear as the lower jaw was depressed. In addition, he indicated that any analysis of muscle angle should include the postorbital ligament when it is present. Here I shall present such an analysis in detail because it is of considerable importance for understanding adaptations of the kinetic mechanism, whereas the effect of muscle angle on a simplified system of weightless and frictionless levers as presented by Zusi (1959) and Bock (1964, pp. 16, 17) is probably irrelevant to the situation in the avian jaw, even in birds lacking a postorbital ligament.

To explain the relationship between the postorbital ligament and motion of both jaws through force analysis, it is necessary to discuss two important variables diagrammed in figure 6: first, the relative lengths of the segments from the mandibular attachment of the postorbital ligament to the center of rotation of the jaw articulation (A) and from the ligament's attachment to the insertion of the depressor mandibulae (B); and second, the angle of the depressor mandibulae in relation to its neutral axis. The force of the depressor mandibulae (F) can be replaced by two components, H and V, running in line with and vertical to the force arm B. To determine the effect of these components on the quadrate, one must transfer both components, H' and V', to the jaw-quadrate articulation. The clockwise rotational component V' is increased by the amount $V' = \frac{V \times B}{A}$ whereas the counterclockwise component H' remains the same, and

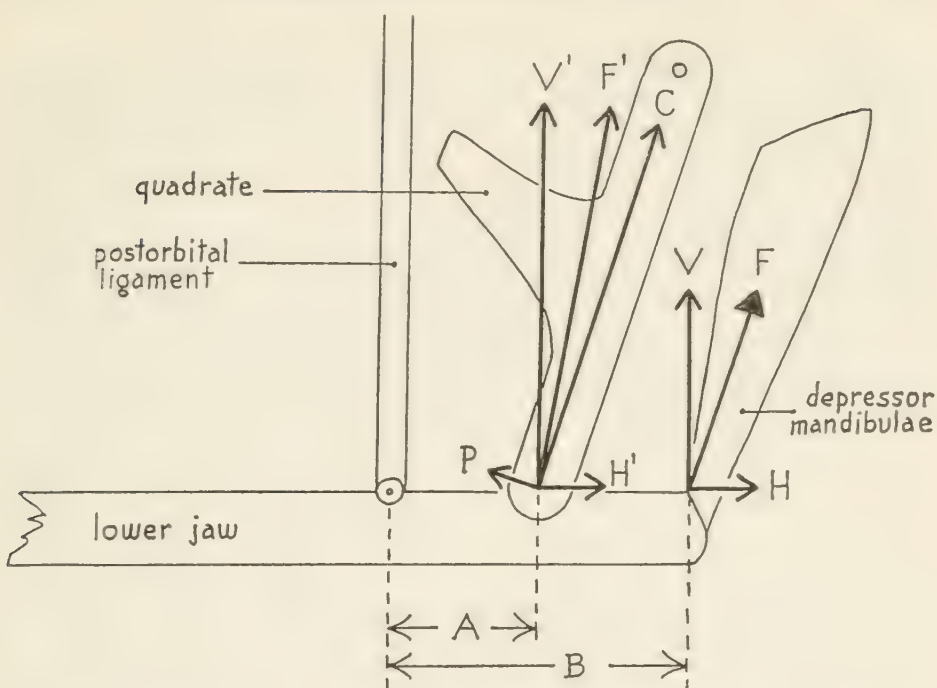


FIGURE 6.—Diagram of forces produced by the depressor mandibulae in a simplified supporting system of the lower jaw. (F =resultant force of depressor mandibulae; V and H =rectangular components of F ; $H'=H$ transferred to quadrate articulation; $V'=V$ transferred to quadrate articulation and increased in relation $V'=\frac{V \times B}{A}$; F' =resultant of components V' and H' ; P and C =rectangular components of F' ; A =work arm from fulcrum at attachment of postorbital ligament to quadrate; B =force arm from postorbital ligament to insertion of depressor mandibulae.)

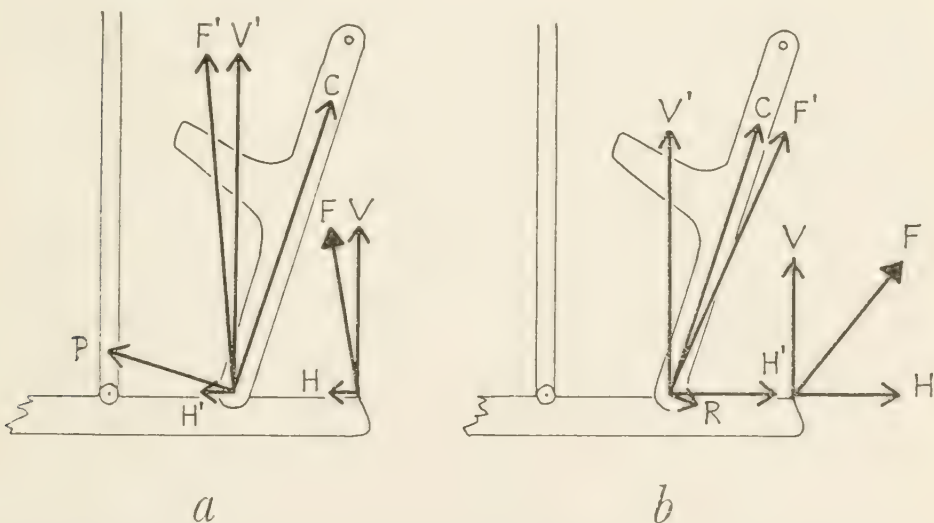


FIGURE 7.—Effect of the angle of the depressor mandibulae upon motion of the upper jaw through the postorbital ligaments: *a*, protraction force P increased by counterclockwise shift of F (compare with fig. 6); *b*, retraction component R produced by clockwise shift of F (compare with fig. 6). (Symbols defined in fig. 6.)

the new resultant force is F' . (Clock directions herein always refer to the skull as viewed from its left side.) The rotational effect of force F' on the quadrate is P . It is clear that variation in the angle of the depressor mandibulae can increase or reduce P (fig. 7a) and that the muscle-ligament combination could even produce retraction of the upper jaw (fig. 7b). The neutral angle of the muscle is the angle at which contraction of the depressor mandibulae produces no motion of either jaw. Bock's force analysis (1964, fig. 9) is incorrect because he neglected to transfer the backward component of force of the depressor mandibulae (H in fig. 6 of this paper) to the jaw articulation along with the upward component (V). It is not true that the presence of the ligament would cause protraction upon contraction of the depressor mandibulae under all conditions, as implied by his analysis; rather, the force and amount of protraction obtained and the amount of depression of the lower jaw as well depend upon the two variables mentioned above, and these forces could reach zero (the neutral state) under conditions that are not very different from those existing in birds. The conditions producing a neutral angle of the depressor mandibulae are not found in birds when the jaws are closed because such conditions would prevent opening of *both* jaws. Birds in which the geometry of the jaw-support system departs most strongly from a neutral arrangement probably represent special adaptations for coordination of the jaws through the depressor mandibulae.

Just as components V' and H' are altered by variations in the angle of F , their effect upon protraction varies with changes in the relative lengths of the force and work arms (B and A) when the muscle angle remains the same. If B is increased relatively more than A , V' increases but H' remains the same, with the result that P increases. By contrast, P may be reduced to zero if B becomes relatively shortened.

Were the line of force of the depressor mandibulae to parallel the long axis of the quadrate (regardless of its angle to the long axis of the mandible), its protraction force (P) would be zero only when B equalled A . In birds, B is always greater than A and the depressor commonly is nearly parallel to the long axis of the quadrate with the result that a protraction force exists. The *force* of protraction can be increased by relative lengthening of the retroarticular process of the mandible or by shifting the angle of pull of the depressor muscles in a counterclockwise direction, or by both. The *amount* of protraction possible depends upon the relative lengths of A and of B , of the quadrate, and of the muscle fibers in the depressor mandibulae, as well as the geometry of the palate and upper jaw. A relative increase in A with respect to B would increase the degree of protraction with a given contraction of the depressor muscles, at the same time re-

ducing the force of protraction. The attachment point of the post-orbital ligament, however, is never far in front of the jaw articulation as this would reduce the amount by which the lower jaw could be depressed.

During depression of the lower jaw by the depressor mandibulae muscles, the resultant force of each depressor muscle shifts in a clockwise direction relative to the bones. It is possible that the geometry of the entire ligamentary mechanism is such that, in some birds, the system reaches a neutral condition before the mandible is depressed to the limits allowed by the jaw articulation alone. Full contraction of the depressor mandibulae thus would stabilize both jaws in an opened position without permitting excessive strain on the jaw articulation or kinetic articulations that might occur in the absence of the ligament.

Zusi (1959) postulated that birds that force their jaws open against environmental resistance (probers, gapers) may derive a protraction effect through the depressor mandibulae in that the point of resistance to depression of the lower jaw creates a new fulcrum, replacing that of the postorbital ligament. (In figure 6, A and B would then extend from the point of resistance near the tip of the jaw to the quadrate and to the depressor mandibulae, respectively.) In the light of the above analysis, it is clear that the mechanism would work effectively only if F were shifted in a counterclockwise direction to offset the loss of protraction force incurred by the relative increase in the ratio of A to B, or if the ratio were reduced by elongation of the retroarticular process of the mandible. I have not carried the analysis for any particular species far enough to be able to say whether or not the depressor mandibulae alone could produce protraction of the upper jaw in the presence of environmental resistance on both jaws. Bock (1964, p. 17) pointed out that the analysis is difficult and must include both jaws. It seems likely, however, that species with a strong forward component to the pull of the depressor mandibulae would be capable of stronger gaping (forceful opening of both jaws), not only by increasing the force of depression of the mandible, but also by favoring conditions for protraction of the upper jaw as well. The validity of the difference between the adaptations found in the depressor mandibulae muscles of *Sturnus vulgaris* and gapers of the Icteridae postulated by Zusi (1959) is thus strengthened by the above analysis although the explanation originally proposed was incorrect.

In species lacking a functional postorbital ligament, any structure that resists depression of the lower jaw will cause protraction of the upper jaw through forces similar to those diagrammed in figure 6 but only in proportion to the amount of resistance offered by the structure.

The large adductor muscles of the jaw, and in particular *M. pseudotemporalis superficialis*, which in many species lies in a position comparable to that of the postorbital ligament but medial to it, may serve this function in a passive manner. The pseudotemporalis superficialis, often highly tendinous, might functionally replace the ligament by active contraction as well. There is clearly a great need for experimental approaches to the problems of avian kinesis to test the important specific questions that now can be asked.

Although the effect of muscle angle on protraction of the upper jaw in the absence of any restraining forces anterior to the jaw articulation

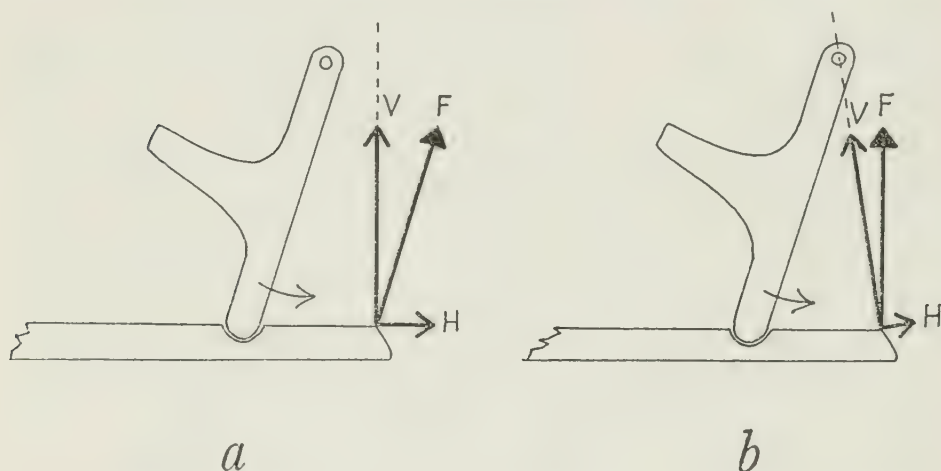


FIGURE 8.—Diagram of forces on the lower jaw and quadrate from the depressor mandibulae in the absence of the postorbital ligament: *a*, with unrestricted rotation of the lower jaw, H serves to retract the quadrate and V serves primarily to rotate the lower jaw (H reaches zero when F is perpendicular to the lower jaw); *b*, with reduction or loss of rotation at the jaw articulation, H retracts the jaw-quadrate unit and V has no rotational effect (H reaches zero when F passes through the otic articulation of the quadrate). (F =resultant force of depressor mandibulae; H and V =rectangular components of F ; curved arrows==motion of quadrates under conditions illustrated.)

probably seldom has a bearing on jaw motion in birds, I shall discuss it briefly because it has been mentioned in the literature. If the struts and hinges of the model shown in figure 8*a* were weightless and frictionless, the effect of muscle angle would probably be that described by Bock (1964, p. 17)—that is, protraction or retraction would depend only on the muscle's pull forward or backward from a 90-degree angle (the neutral angle) to the mandible. Were there friction or any other resistance to rotation at the jaw-quadrate hinge, protraction would occur if the line of pull of the muscle passed ahead of the cranial articulation of the quadrate and retraction would occur if it passed behind the articulation (fig. 8*b*). The neutral angle would

pass through the cranial articulation. In the most common circumstances there is some form of resistance to depression of the mandible anterior to its articulation, and the line of pull of the depressor then has relevance for protraction only if it angles forward from the neutral angle, which is determined by the geometry of the whole system as already explained. In any case, an evolutionary shift in the direction of pull of the depressor mandibulae in a counterclockwise direction represents a functional change along the continuum "retraction—neutral—protraction" with respect to the muscle's influence on the upper jaw.

Coordination and Independence of Jaw Action

POSTORBITAL LIGAMENT.—Coordination of the jaws through the postorbital ligament (or its functional equivalent, as in the lacrymo-mandibular ligament in certain ducks) requires that the ligament attach on the mandible anterior to the jaw articulation. Should the ligamentary attachment approach the jaw articulation (or should A in figure 6 be reduced) the amount of protraction obtained through the ligament would be correspondingly reduced. Coordination would reach zero when the ligamentary attachment lay opposite the jaw articulation. By manipulation of the jaws of fresh specimens of the sooty tern (*Sterna fuscata*), I found that a pull on the depressor muscles caused very little forward or backward displacement, relative to the braincase, of the postorbital ligament and lower jaw during depression of the jaw; instead, the quadrate was displaced forward and the upper jaw raised. On the other hand, when motion of the upper jaw was restricted and the quadrates thereby held stationary, depression of the lower jaw was accompanied by a backward shift of the lower jaw and postorbital ligament relative to the braincase and quadrates. (Strict limits to this backward shift were set by the articular jugo-mandibular ligament.) Whether the jaw shifts backward or the quadrate forward, the shift is enough to bring the attachment point of the postorbital ligament closer to the rotation center of the jaw articulation and to reduce the coordinating action of the ligament. (Manipulation of the jaws was accomplished through pulling on the depressor mandibulae muscles or by applying pressure on the jaw at their points of insertion. Manipulation of the jaws by their tips may give different results that do not correspond to actions of the depressor mandibulae muscles.)

The ability of the lower jaw to shift backward with respect to the quadrate may be deduced from the jaw motions of an evening grosbeak that is hulling sunflower seeds. The bird moves its lower jaw to the right or left of the upper jaw to facilitate manipulation of the seeds.

Because the two quadrates are held in comparable positions by the jugal and palatal struts and therefore cannot move independently, one of the mandibular rami must slide backward along the quadrate while the other remains in place during displacement of the jaw to the side. The possibility of backward displacement of the lower jaw in the domestic chicken, although less obvious during normal feeding of the bird, can be demonstrated by manipulation of fresh heads. I conclude that the shift of the ligamentary fulcrum toward the jaw articulation is one means of overcoming strict "coupling" by the postorbital ligament.

In addition to the experiments already described, three instances of independent jaw action in birds possessing a well-developed post-orbital ligament have come to my attention. Two of these represent jaw motions during yawning—one in the night heron (*Caltherodias leuconotus*) observed by me (see p. 24) and the other described by Yudin (1958, p. 168), who gave the sequence of jaw motions in a gull as follows: (1) lower jaw maximally depressed, (2) upper jaw raised, (3) upper jaw lowered, and (4) lower jaw raised. The third instance appears in a series of photographs of the great snipe (*Capella media*) taken by P. O. Swanberg (1956). In these birds, protraction of the upper jaw is restricted to the tip of the bill, where it would be readily evident by comparison with the immovable base-line provided by the rest of the upper jaw. Several photographs show the closed bill and its slight downward curve. Plate 74 shows the lower jaw slightly open and in plate 73 quite widely open, but in neither case is there any change in the downward curve of the tip of the upper jaw and thus no protraction or coupling.

Jaw Articulation

One important question remains to be answered: how did the depressor mandibulae effect protraction in the evening grosbeak and in the domestic chicken after removal of the postorbital ligaments? In addition to coupling of the two jaws by the postorbital ligament, Bock (1964, p. 18) briefly referred to another type of coupling through an interlocking of the condyles of the quadrate and articular with the result that the mandible cannot be depressed without forward motion of the quadrates. He listed certain families of birds in which this interlocking is well or moderately developed, citing *Balaeniceps* as a prime example, but he offered no explanation of this action. Although neither of the species used for experiments in the present study is coupled through the jaw articulation to a high degree, a discussion of the mechanism in *Balaeniceps* will serve to introduce the general problems of coordination of the jaws through the jaw articulation.

In *Balaeniceps* (fig. 9), the quadrate has two main condylar surfaces, the inner of which (medial condyle) forms a double crest lying parallel to the plane of movement of the quadrate. The lateral condyle is somewhat curved, lying approximately perpendicular to the crest and to the plane of quadrate motion (its posteromedial

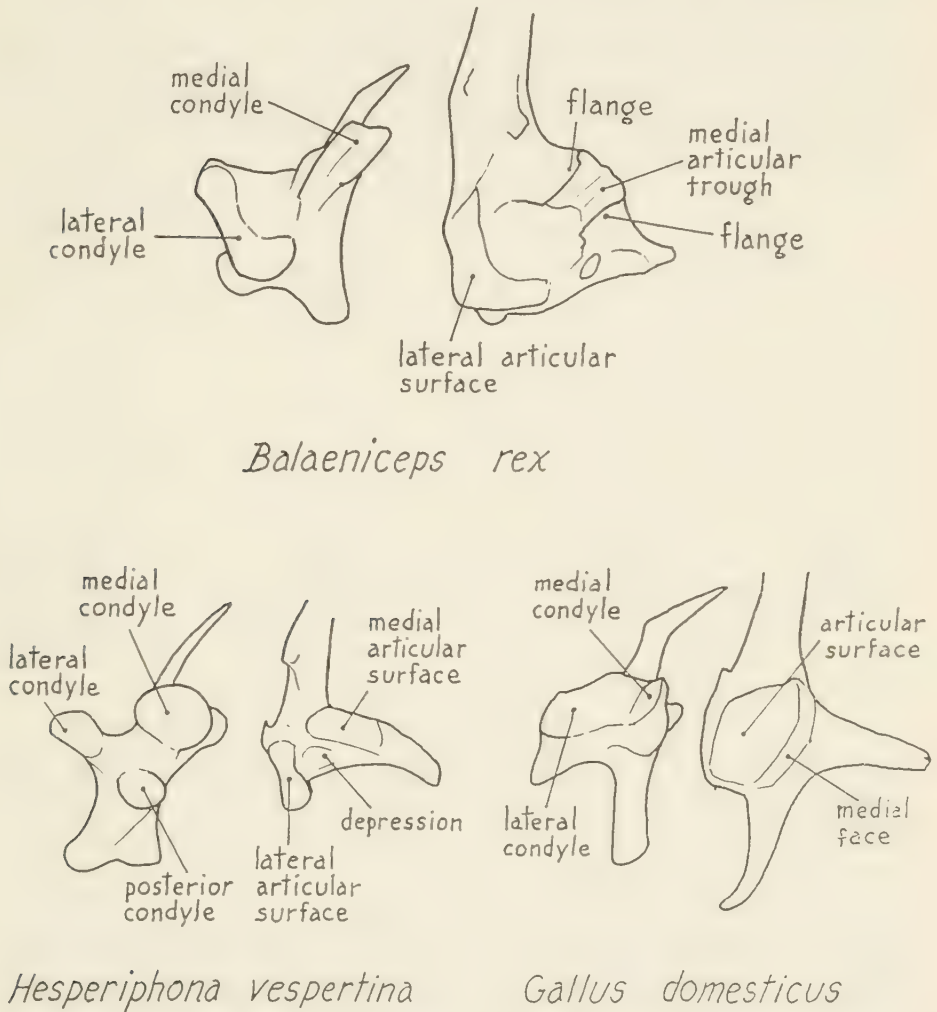


FIGURE 9.—Structure of jaw articulation in *Balaeniceps rex*, *Hesperiphona vespertina*, and *Gallus domesticus*. (Ventral view of right quadrate and dorsal view of left articular shown for each species.)

portion is expanded into a prominent condyle that is often referred to as the posterior condyle of the quadrate). These condyles fit into corresponding depressions or surfaces of the articular bone, and flanges on the upper edges of the medial articular trough grip the crests of the medial condyle of the quadrate, holding the articulated lower

jaw of a completely cleaned skull in place, as described by Böhm (1930) and others. Partly because of the gripping flanges but primarily because of the structure of the crests, trough, and lateral articular surfaces, the lower jaw can be depressed or raised only if the quadrate and articular surfaces slide along each other in the direction dictated by the crests and troughs. During depression of the jaw, this could be accomplished either by a passive spreading of the rami of the jaw as they slide backward and upward along the condyles of fixed quadrates; or the quadrates could move forward and inward while the jaw was depressed without producing a lateral spreading of the rami (fig. 10). Whether or not there is a flange grip and a deep and well-defined trough of the articular as in *Balaeniceps*, the condyles of many diverse orders of birds are arranged in such a

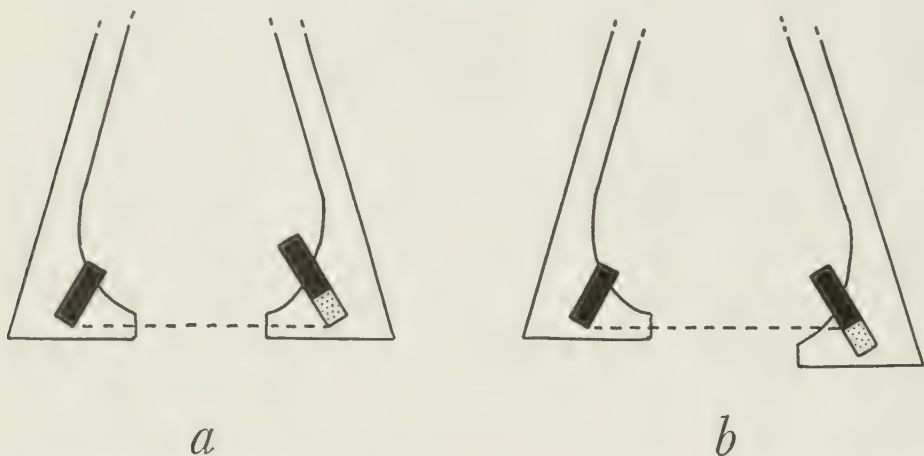


FIGURE 10.—Diagrams of relative positions from dorsal view of ramus of lower jaw and quadrate (black) when the jaw is closed (left ramus), and when depressed (right ramus): *a*, quadrate moves anteromedially; *b*, ramus moves posterolaterally.

way that the planes of motion within the two jaw-quadrates converge anteriorly like those of *Balaeniceps* and downward rotation of the mandible therefore requires either posterolateral spreading of the rami or anteromedial motion of the quadrates. Protraction of the upper jaw thus will accompany depression of the lower jaw if resistance to spreading of the rami is greater than resistance to forward and inward rotation of the quadrates (which of course depends upon the combined resistance of all flexible portions of the upper jaw and palate). Protraction would be prevented if the quadrates were held in place, but depression of the lower jaw could still occur through spreading of the rami. Birds vary greatly in the ease of motion of the palate and upper jaw and in the lateral flexibility of the rami; the extent to which the rami may contribute to protraction

through the jaw articulation unfortunately has not been established for any species to my knowledge. Manger Cats-Kuenen (1961, pp. 18, 19) explained the coupling action of the jaw articulation in detail and concluded that independent motion of the two jaws in the hornbill *Rhinoplax vigil* was impossible because the rami had no lateral flexibility. I believe, however, that the flexibility necessary for independent depression of the mandible exists in *Rhinoplax* because even in a dried skull it is easy to depress the lower jaw by pressing on the retroarticular processes. When the kinetic mechanism is immobilized in the dried skull, the rami nevertheless readily spread apart during depression of the mandible.

It is probable that the conformation of the jaw-quadrates articulation played a role in protraction through the depressor mandibulae in the evening grosbeak (lacking a postorbital ligament) and in the chicken after removal of the postorbital ligament (fig. 4) although the mechanism appears to be different in the two species. The condyles of the jaw articulation of the domestic chicken are quite different from those of *Balaeniceps* (fig. 9), but both species have lateral surfaces providing broad support and medial surfaces providing guidance. In *Gallus domesticus* the medial condyle of the quadrate slides along a well-defined medial face (corresponding to the trough of *Balaeniceps*) of the broad, flattened articular surface. The medial faces of the two rami converge anteriorly. Depression of the lower jaw in the chicken, therefore, requires spreading of the rami or anteromedial motion of the quadrates just as in *Balaeniceps*. The possibility that resistance to lateral spreading of the rami in the chicken is enough to raise the upper jaw is suggested by the occurrence of protraction after removal of the postorbital ligaments.

The structure of the jaw articulation in the evening grosbeak differs sharply from that of the domestic chicken in that the quadrate possesses three knoblike condyles and in that the articular has a deep depression between its two articular surfaces (fig. 9). There is no well-defined trough of the articular that would serve to guide the motion of the rounded medial condyle of the quadrate; rather, the medial condyle rests on the top of a narrow medial articular surface that slopes downward and terminates just in front of the condyle when the jaws are closed. As the lower jaw is depressed, the medial and posterior condyles of the quadrate slide forward on the inclined surfaces of the articular to occupy the space or depression in front. With contraction of the depressor mandibulae, protraction appears to be caused by pressure of the articulation surfaces of the lower jaw on the quadrate condyles. The quadrate slides forward easily because of the slope of the articular surfaces.

Discussion

I have been concerned primarily with the functional properties of only one paired muscle as it acts within the kinetic systems of various species of birds (see fig. 11). The depressor mandibulae muscles serve principally to open the upper and lower jaws simultaneously. In most species the most powerful agents for protracting the upper jaw are undoubtedly the protractor quadrati et pterygoidei muscles, which

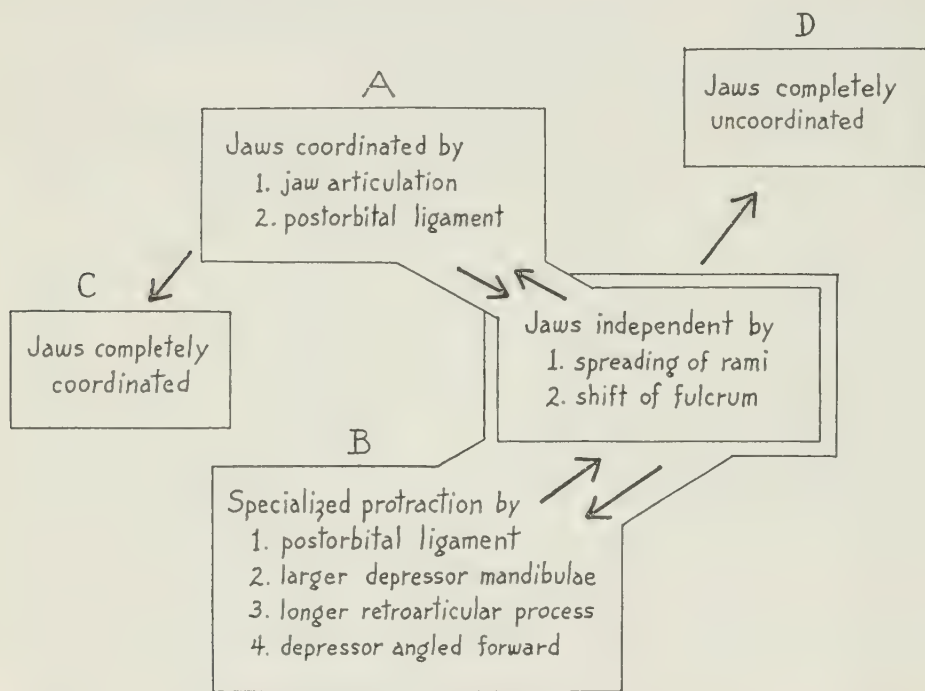


FIGURE 11.—Diagram of kinetic possibilities through the depressor mandibulae in the avian jaw: Species A has weakly coordinated jaws that may be moved independently. Species B has developed stronger protraction of the upper jaw through the mechanisms of coordination but can also overcome coordination. Species C has no capacity for independent jaw action, whereas species D has no coordination through the jaw-quadrates complex. (C and D are hypothetical.)

almost certainly come into play during maximum or forceful gaping. The depressor mandibulae, however, may be the sole or principal muscles opening both jaws when extensive or powerful opening of the jaws is not required, as in taking small food items from a substrate.

The mechanisms by which the depressor mandibulae can protract the upper jaw involve the angle of the muscle, the angle of sliding of the jaw-quadrates surfaces, the rigidity of the rami of the lower jaw and of the kinetic mechanism, the presence of a postorbital ligament or a comparable ligament, the length of the retroarticular process of

the mandible, the presence of ligamentous adductor muscles, and the resistance to depression of the lower jaw by environmental forces. Other features may be involved as well and a variety of factors probably contribute to jaw motion in each species. The mechanisms are developed to varying degrees in different groups of birds. Only by understanding their functional properties can we recognize convergence, independent divergent solutions to similar problems, and adaptive radiation in the kinetic mechanism. A survey of such trends in birds or in any group of birds has not yet been made in detail, but a few cases of variation in the depressor mandibulae complex should be mentioned here.

Certain birds that habitually probe into flowers or fruit show a combination of features that suggest a special role of the depressor muscles for protracting the upper jaw. Representatives of the "Coerebidae" (*Coereba flaveola*), Zosteropidae (*Zosterops annulosa*), and Drepanididae (*Vestiaria coccinea*) display large depressor muscles, well-developed retroarticular processes of the mandible, and strong postorbital ligaments (Beecher, 1951a, pp. 277, 283; Moller, 1931, p. 126). Beecher (1951a, p. 285) states that "The Neotropical nectar-adapted tanagers are non-gapers. In none of them is *M. depressor mandibulae* more highly developed than in *Cyanerpes* . . . and it is apparent that these species simply insert the bill into flowers and sip nectar." Moller (1931, p. 110), however, illustrates *Dacnis cayana* as having a large depressor mandibulae, which, combined with its strong postorbital ligament, long retroarticular process, and relatively straight culmen and gonys strongly suggests that gaping is among its feeding patterns. Various members of the Icteridae display these same features and, in addition, have the depressor muscles angled well forward (Beecher, 1950, 1951b). Associated with this highly developed gaping adaptation is the straight culmen and gonys so characteristic of many icterids, essential for effective parting of the grass, earth, or flesh of a fruit with the outer edges of the bill. The starling (*Sturnus vulgaris*) is convergent with the icterids, especially *Sturnella*, in some features related to gaping but divergent in others (Zusi, 1959). Certain parrots have the depressor mandibulae muscles enlarged and strongly angled forward (*Nestor notabilis* and *Cyanorhamphus novae-selandiae*, illustrated in Hofer, 1950, pp. 457, 463). The retroarticular process is well developed but the postorbital ligament is lacking. Parrots are well known for their extraordinary mobility of the upper jaw, but no comparative information on this property in the Psittacidae is available. Among the probing Scolopacidae, the woodcock (*Scolopax*) shows special development of the depressor mandibulae and retroarticular process of the mandible (see Marinelli, 1928, fig. 8), possibly in relation to the need for

protraction in relatively firm earth. Galliform and anseriform birds display a long retroarticular process of the mandible but neither group has an obvious need for powerful depression of the lower jaw. Rather, the process may be related to kinetic action through the depressor mandibulae muscles.

The examples just given represent birds in which there is a need for strong, extensive, or repeated protraction and in which a combination of features associated with the depressor mandibulae is adapted to accomplish or to aid protraction. Other examples can be found among the passerine birds (see illustrations in Beecher, 1953, pp. 302, 318), but the elucidation of the adaptive radiation within these groups remains a challenge for the anatomist.

EVOLUTION OF THE INTERLOCKING JAW ARTICULATION.—Bock (1964, p. 37) postulated an obligatory coupling of the jaws through the postorbital ligament and thus found no explanation for the presence of two strict coupling mechanisms (postorbital ligament and jaw articulation) in the same species or for the evolution of jaw-articulation coupling. Explanations for these phenomena are possible, however, with the knowledge that coupling may be bypassed and that the postorbital ligament serves functions other than coupling. The fulcrum provided by the postorbital ligament causes the posterior portion of the depressed mandible to be rotated upward and forward. One result is that the mandible pushes the quadrates forward at least during the initial phases of depression, but another consequence is that a firm contact of the jaw and quadrate surfaces is assured throughout motions of the lower jaw. Without the postorbital ligament (or some functional equivalent) the anterior surfaces of the jaw articulation would tend to separate during depression of the mandible. As the condyles of the jaw articulation may serve to coordinate jaw motions, the ligament would enhance coordination by keeping the articulation surfaces in close apposition. The postorbital ligament could thereby play an important part in the evolution of the interlocking grooves and ridges of the jaw articulation. Support for the lower jaw through interlocking in a species such as *Balaeniceps* is lost quickly if the rami are spread slightly or the quadrates displaced anteromedially at any given position of the lower jaw, and it cannot be assumed that ligamentary supports are unnecessary in specialized "articulation-coupled" forms. The postorbital ligament is a structure that probably developed early in the evolution of modern birds and has played a role in the evolution of increased articulation-coupling in various groups while being reduced or lost in others. Its loss may be associated with the development of maximum independence of jaw motion.

FUNCTIONS OF KINESIS.—Bock (1964, pp. 25–31) discussed six possible functions of kinesis: (1) maintaining the mandible in the closed position, (2) gaping, (3) maintenance of the primary axis of orientation of the bill, (4) faster closing of the jaws, (5) more widespread and even distribution of jaw muscle attachment, and (6) shock absorbing. Of these, I believe that the first is doubtful because it requires the hypothesis of strict coupling of the jaws for its explanation and because the ligament does not hold the lower jaw closed (at least in *Gallus domesticus*). The third and sixth are probably of widespread importance—the third because many species rely on rapid grasping of tiny food items or of moving prey and the last because of the light construction of the jaws and palate in birds.

I believe that a primary advantage of kinesis is that it provides increased possibilities for diversity of manipulation by the jaws. Although birds lack teeth, they nevertheless must perform many manipulative tasks with the bill such as the capture, holding, orientation, manipulation, and swallowing of food, nest-building, preening, defence, and other activities. Two fundamental features of skull construction in birds serve, in combination with kinesis, to enhance the diversity of manipulation.

First, the tomial edges of the upper jaw are drawn forward when raised and backward when lowered (fig. 12*b*) because the flexible point of attachment of the upper jaw and cranium lies above the plane of the tomia. In most birds the articulation of the lower jaw lies below the tomial plane and there is a similar forward and backward motion of the tomium during depression and adduction of the lower jaw. A food item being constricted by the jaws, therefore, is wedged backward toward the throat rather than pushed forward as it would be by a straight pair of tongs (fig. 12*a*). Immobility of the upper jaw would reduce considerably this effect. Unfortunately, I can say nothing about its significance for the living bird although its existence can scarcely be doubted. The effect is greatest in relatively short and deep bills, where it may provide more effective seed-cracking forces or help to keep seeds from slipping forward in the bill during nibbling.

A second type of manipulation is made possible by the anterior placement of the flexible cranial attachment of the upper jaw relative to the articulation of the lower jaw (fig. 13). The upper jaw thereby rotates about a shorter radius than the lower, and the tomial edges can be opposed in a greater variety of ways than would be possible otherwise, especially if the upper jaw can be retracted below the resting position as discussed by Beecher (1951*b*, p. 413) and Yudin (1965, p. 68). Bock (1964, pp. 23, 24) argued against such retraction in a coupled skull, but I have shown here that coupling can be over-

come readily, at least in *Gallus domesticus*, and the theoretical objections to retraction of the upper jaw below the resting position thus are eliminated. While watching a night heron (*Caltherodias leuconotus*) at close range in the New York Zoological Park, I observed retraction of the upper jaw when the bird was yawning. Just before

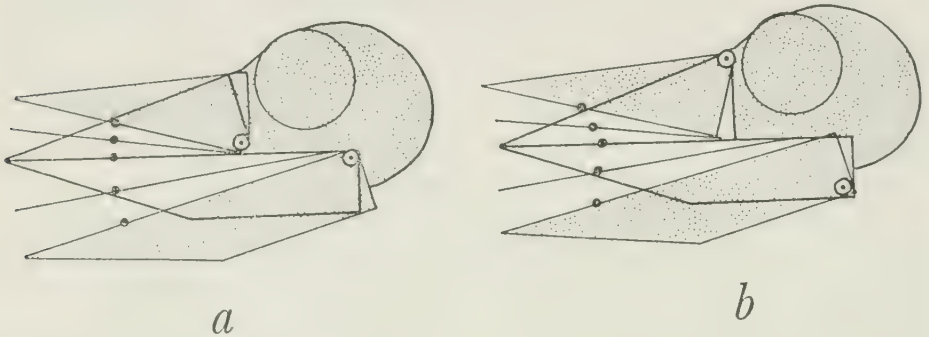


FIGURE 12.—Diagrams showing positions of tomial edges and of particular points (dots) on the tomia during motions of the two jaws: *a*, when centers of jaw rotation lie close to tomial planes; *b*, when centers of jaw rotation lie far from tomial planes.

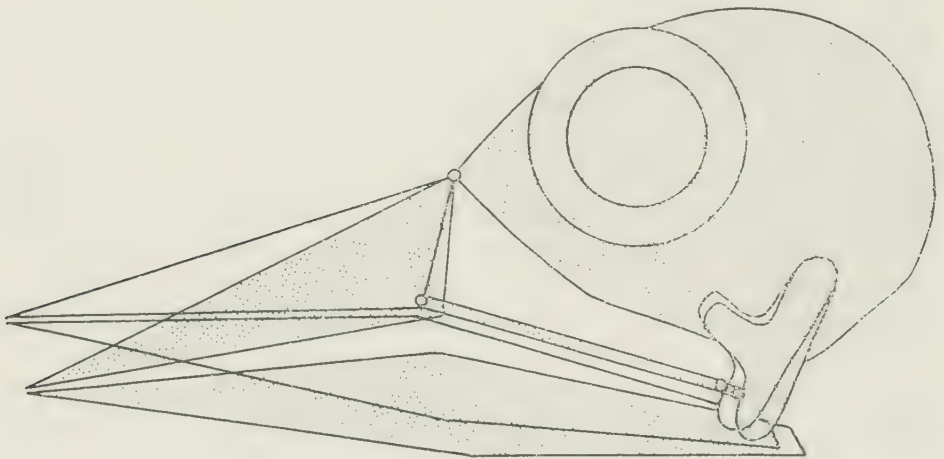


FIGURE 13.—Diagram of the avian skull showing retraction of the upper jaw beyond the normal closed position. Because the lower jaw articulates well behind the cranial bending axis of the upper jaw, the manipulative possibilities of the jaw are increased. Biting with the bill tip as shown would not be possible if the jaws were of equal length.

raising the depressed mandible to its resting position, the bird retracted its upper jaw below the resting position with the result that only the tips of the jaws were touching and the gap between the bases of the jaws was clearly visible. Herons have the postorbital ligament well developed and are also “coupled” through the jaw-

quadrate articulation. It thus appears that retraction of the upper jaw beyond the resting position is one of the capabilities of avian kinesis. Its importance lies in the potential for increased diversity of manipulation by the bird's beak.

In studying the functional significance of the palatine process of the premaxilla, Bock (1960) postulated that there are two methods of seed-cracking used by heavy-billed finches. The first he called "the nutcracker method," characterized by a kinetic upper jaw and equal development of the adductors of the mandible and the retractors of the palate. He ascribed this method to the emberizine finches and richmondenine finches. By contrast he claimed that the cardueline finches employ "the vise method," which he describes (p. 427) as follows:

In the specialized carduelines, the upper jaw has lost its mobility; it is a nearly stationary block against which the mandible presses. Heavy bosses of bone (the lateral flanges) and rhamphotheca distribute the shocks associated with the cracking of the seed evenly to all parts of the braincase. Only the adductor muscles are well developed in the cardueline finches; in fact, the muscles associated only with the movement of the upper jaw have become small and are on the verge of becoming functionless.

We have seen that the evening grosbeak—one of the heavy-billed cardueline finches—has a kinetic upper jaw that operates even in the absence of contraction by its prime protractors, the *M. protractor quadrati et pterygoidei*. In order to exert a seed-cracking force, the upper jaw must be moved in opposition to the adduction of the lower jaw or held stationary while force is exerted by both jaws, requiring in either case a powerful *M. pterygoideus*. It thus seems doubtful that the vise and nutcracker methods of jaw action are of general validity although certain species may have become specialized in one direction or the other (e.g., *Coccothraustes* [Sims, 1955]). Kinesis may be important to seed-cracking forms for manipulation of seeds and for the application of biting forces from different angles as explained above.

The role of the depressor mandibulae in avian kinesis can at present only be inferred from a knowledge of its functional-anatomical properties. My findings suggest that through linkages of various kinds the depressor mandibulae may serve to open both jaws simultaneously when strong protraction is not required, whether or not a postorbital ligament is present. In those species with a strong postorbital ligament and/or interlocking condyles of the jaw articulation and especially in those in which the muscle angles far forward from its insertion and in which the retroarticular process of the mandible is well developed, the depressor may have a more precise and powerful effect in opening both jaws. Further investigations of these problems through comparative morphology, physiology, and behavior may be

expected to broaden our understanding of structural diversity in the avian skull.

Summary

Experiments on the action of *M. depressor mandibulae* in *Gallus domesticus* and *Hesperiphona vespertina* demonstrate that the muscle causes protraction of the upper jaw as well as depression of the mandible. The coordination of both jaws is enhanced by the presence of a postorbital ligament and/or by modifications of the jaw-quadrates articulation. The mechanism of protraction through the postorbital ligament and depressor mandibulae is explained through force analysis and it is shown that the force and amount of protraction vary with muscle angle and length of the retroarticular process of the mandible. Independence of jaw motion may be achieved by a backward shift of the mandible or by spreading of the mandibular rami. The role of the postorbital ligament in the evolution of coordination of the jaws through the jaw articulation is presented. Two general properties of avian skull structure are shown to diversify the manipulative capabilities of the bill in a kinetic skull.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3608

Studies of Neotropical Caddis Flies, IV New Species from Mexico and Central America

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During the past few years the insects of Mexico and Central America have been collected extensively by several members of the Smithsonian Institution's Department of Entomology. In 1963 W. D. Duckworth and D. R. Davis collected in northeastern Mexico (A.P.S. grant J-493). P. J. Spangler collected widely in Mexico in 1964, and, in 1965, on another trip, he collected as far south as Costa Rica (N.S.F. grant GB-1697). El Salvador, Costa Rica, and Panama were sites of collections in 1965 by W. D. Duckworth (N.S.F. grant GB-1800). I collected widely in Mexico and Guatemala in 1965 and 1966 (N.S.F. grant GB-2616). In addition to this material, other specimens are included whenever available. The holotypes of all new species are deposited in the U.S. National Museum.

Thirty-one species are described as new in this paper. There are many more probable new species in the collections, but because of their close relationship to known species they are not described herein. It is hoped that in time additional material will show whether or not these specimens represent mere variation or in fact are valid species.

RHYACOPHILIDAE

Atopsyche hidalgoi, new species

FIGURES 1, 2

This species is closely related to *A. tripunctata* Banks, from which it differs in possessing a shorter, broader paracercus, and in lacking the forked dorsal process of the aedeagus.

Adult. Length of forewing 10–11 mm. General color brown; wings with long, erect, brown, golden, and black hairs. Male genitalia: Fifth segment with an anterolateral process about one-fourth length of segment. Sixth sternum with an apicomesal process two-thirds length of segment, process of seventh sternum one-third length of segment. Paracercus broad, slightly longer than filicercus, bearing two teeth dorsally, ventrally with a hirsute ridge, which ends in a blunt tooth anteapically. Filicercus elongate, clavate. Clasper with basal segment having an inner ridge; apical segment with dorsal margin inrolled near apex. Aedeagus elongate with a slender inner rod, with a strong lateral spine at midlength, apex bearing dorsally a laterally directed tooth.

Holotype, male: Mexico (Mexico), Las Cruces National Park, La Marquesa, 3000 m elevation, July 5–9, 1965, Flint and Ortiz.

Paratypes: Same data, 4 ♂. Mexico (Morelos), Lagunas Zempoala National Park, July 10–11, 1965, Flint and Ortiz, 1 ♂.

GLOSSOSOMATIDAE

Culoptila montanensis, new species

FIGURES 3, 4

The species is close to *C. amberia* Mosely; however, the genitalia possess a complex of sclerites ventrally that Mosely does not show in *C. amberia*, and the internal spine of the aedeagus is less than half as long as that of *C. amberia*.

Adult. Length of forewing 3.5 mm. Color uniformly dark reddish brown; wings with anastomosis bearing a few paler hairs, most noticeably at posterior margin. Male genitalia: Sixth sternum with a short broad, subapical process. Tenth tergum with ventral arm well developed, apex produced and pointed, in ventral aspect horseshoe shaped. Ventrally with a pair of processes bearing a few apical hairs, a broad plate above processes curving upward and outward and bearing internally a curving rodlike process whose tip is directed posteroventrally. Aedeagus capsule-like, apex developed dorsally into a hoodlike structure, internally bearing a single heavily sclerotized spine about one-third length of aedeagus.

Holotype, male: Guatemala (El Progreso), Finca La Cajeta, Aug. 12-20, 1965, Flint and Ortiz.

Protophila laterospina, new species

FIGURE 5

Since this species bears a lateral spine from the aedeagus, it is placed in group 1. It is probably closest to *P. alexanderi* Ross, from which it differs in the longer, more deeply divided eighth sternum, very long, slender spine from the aedeagus, and the lateral spine from the tenth tergite.

Adult. Length of forewing 4 mm. Uniformly brown, faintly paler along anastomosis. Male genitalia: Sixth sternum with a pointed apicomesal process. Eighth tergum with posterior margin bearing a dense brush of setae; sternum produced into two long terete processes. Ninth segment rounded anteriorly, sternum barely produced posteriorly. Tenth tergite heavily sclerotized, dorsal margin with a shallow rectangular emargination, dorsoapical angle slightly produced, bearing a strong lateral spine. Aedeagus with a pair of basoventral processes, mesoventrally with two pairs of interlocking processes; paired long slender spines arising laterally, which extend posteriad beneath ventral margin of tenth tergite; apex bearing a heavily sclerotized ventral scooplike process and a dorsomesal spine.

Holotype, male: Costa Rica, La Lola, Apr. 28, 1957, R. D. Shenefelt.

Protophila marca, new species

FIGURE 6

This species is a typical member of Mosely's group 1. It is perhaps most closely related to *P. piacha* Mosely, from which it differs in the very long bifid process of the eighth sternum, dorsal knobs and apical spine of the aedeagus, and the sharply twisted apex of the lateral spine.

Adult. Length of forewing 4 mm. Color fuscous, legs with annulae of pale hairs at apices of segments; wings with a band of whitish hairs at anastomosis, a small spot of white nearer base, and a diffuse band of brownish hairs subapically. Male genitalia: Sixth sternum with an elongate apicomesal process. Eighth segment barely produced dorsally; sternum developed into a pair of very long terete processes, the mesal division extending almost to base. Ninth segment developed into a long ventromesal process, rounded anteriorly. Tenth tergite decurved, uniformly widened apically, in lateral view with an apical tooth that extends as a shelf along the inner ventral margin. Aedeagus with a lateral spine whose tip is sharply

bent upward, dorsomesally with a pair of knobs, apically with a single spine.

Holotype, male: Mexico (Mexico), Las Cruces National Park, La Marquesa, 3000 m elevation, July 5-9, 1965, Flint and Ortiz.

Paratypes: Same data, 37 ♂ and 3 ♀.

Protophila cristata, new species

FIGURE 7

The species belongs to Mosely's group 2, and is perhaps closest to *P. liqua* Mosely. It is distinguished by the lack of processes from the eighth segment, the double teeth ventrally on the tenth tergite, and other differences in all parts of the genitalia.

Adult. Length of forewing 3 mm. Color in alcohol brown. Male genitalia: Sixth sternum with a short apicomeral process. Eighth sternum prolonged, tip bifid, bearing a tooth dorsally just basad of cleft. Tenth tergite short, dorsally developed into a crestlike process, ventrally produced into two teeth. Aedeagus with the typical complex of basoventral processes, apex bearing a C-shaped spine surmounting several smaller spines.

Holotype, male: Mexico (Vera Cruz), Cuitlahuac, Aug. 10-12, 1964, Spangler.

Paratypes: Same data, 3 ♂.

Protophila huasteca, new species

FIGURE 8

This species falls within Mosely's group 2 because there is no lateral spine from the aedeagus. It differs from all other species in this group by the shape of the eighth sternum and the aedeagus, especially in its possession of two pairs of slender ventral rods.

Adult. Length of forewing 3 mm. Color pale brown; forewing with intermingled brown and golden hairs. Male genitalia: Eighth tergum hoodlike with posterior margin heavily sclerotized; sternum strongly sclerotized with a pointed process from lateral margin at midlength, a ventrolateral tooth, and a deep V-shaped mesal excision. Ninth sternum produced into a scooplike structure, united apically with eighth sternum. Tenth tergite decurved laterally, apex developed into a sharp, mesally directed point. Aedeagus with a long paired process lying within ninth sternum, tips directed mesally; apex membranous with an internal spine; two pairs of slender processes ventrally, basal process short, distal process very long with curving apex.

Holotype, male: Mexico (San Luis Potosi), 25 miles north of Tamazunchale, Aug. 3-4, 1963, Duckworth and Davis.

Paratypes: Same data, 4 ♂; same data except June 26, 1965, Flint, 2 ♂; same data except Palitla, June 5, 1966, Flint, 2 ♂.

Protoptila spangleri, new species

FIGURE 9

This species is a relative of *P. liqua* Mosely, from which it differs in possessing very long processes from the tenth tergites and a shorter midventral process from the eighth sternum.

Adult. Length of forewing 3 mm. Color in alcohol uniformly brown. Antennae of male with a series of segments at midlength much broadened. Male genitalia: Sixth sternum with a short apico-mesal point. Eighth sternum produced in a short mesal process that has a broad mesal division. Ninth segment with lateral margins developed into long slender processes. Tenth tergite very narrow, produced into a ventral point and dorsally into a long, ventrally directed, whiplike process. Aedeagus with a ventral scooplike process; at midlength a long pointed process that bears paired teeth laterally; apical membrane with central and lateral hooks.

Holotype, male: Mexico (Vera Cruz), Cuitlahuac, Aug. 10–12, 1964, Spangler.

Paratypes: Same data, 6 ♂.

PHILOPOTAMIDAE

Chimarra duckworthi, new species

FIGURES 10–12

This species is very different from all other described New World species. The structure of the lateral and median lobes of the tenth tergum is unique, as is the elongate, almost semicircular shape of the clasper.

Adult. Length of forewing 4.5 mm. Wings, body, and most of appendages fuscous, femora paler. Male genitalia: Ninth segment with anterior margin rounded, posteroventral projection short, terete. Tenth tergum with an elongate, semimembranous mesal lobe shaped somewhat like a duck's head in profile; lateral lobe bearing a heavily chitinized angled support, sensillae on a slightly enlarged area at the angle of the support, a lightly sclerotized plate with a darker central line beyond the support. Clasper narrow, elongate, tip decurved, pointed; in posteroventral aspect almost semicircular. Aedeagus prolonged into a pointed process ventroapically, internally with two long spines, a ring and rod, and a scabrous pouch attached to a darkened spherical base.

Holotype, male: Costa Rica, Turrialba, Mar. 1–6, 1965, Duckworth.

Paratypes: Costa Rica, La Lola near Matina, Mar. 11, 1965, Duckworth, 2 ♂. Panama, Canal Zone, Feb. 10, 1939, C. J. Drake, 1 ♂.

Chimarra ortiziana, new species

FIGURES 13-16

The relationship of this species to *C. duckworthi*, new species, is shown most clearly by the structure of the aedeagus and the elongate mesal lobe of the tenth tergum. It is distinguished by the narrowed and flared tips of the lateral lobes of the tenth tergum and the broader base of the clasper.

Adult. Length of forewing 4-5 mm. Color fuscous, bases of legs somewhat paler. Male genitalia: Ninth segment rounded anteriorly, mesoventral process about as long as broad. Tenth tergum with a pair of elongate semimembranous mesal processes; lateral lobe broad at base, sharply constricted subapically, tip developed into a dorso-lateral point. Clasper developed apically into a mesodorsally directed lobe, broad and scooplike ventrally. Aedeagus slightly angulate, with an apicoventral spine; internally with a scabrous sac with a darkened globose base, two spines of equal length, and a ring and rod.

Holotype, male: Mexico (Vera Cruz), near Huatusco, July 25-26, 1965, Flint and Ortiz.

Paratypes: Same data, 2 ♂. Mexico (Vera Cruz), route 140, km 387, near El Encero, July 22, 1965, Flint and Ortiz, 1 ♂. Mexico (Vera Cruz), Cordoba, June 7, 1966, Flint and Ortiz, 3 ♂. Guatemala (Izabal), Las Escobas near Matias de Galvez, Aug. 14-16, 1965, Flint and Ortiz, 7 ♂. Guatemala (Suchitepequez), Finca Mocá, June 12, 1966, Flint and Ortiz, 1 ♂.

Chimarra antigua, new species

FIGURES 17, 18

Closely related to *C. setosa* Ross, this species differs from it in possessing a dorsoapical process on the tenth tergite and a broader dorso-mesal shelf on the clasper.

Adult. Length of forewing 4-5 mm. Color totally fuscous. Male genitalia: Ninth segment with a narrow posteroventral keel. Tenth tergite broad, with dorsoapical angle developed into a strong hook that bears the sensillae. Clasper rounded in lateral view, dorsal margin developed into a broad, shelflike mesal process, and a slight ridge subapically also on mesal face. Aedeagus simple, with two spines, one of which is about two-thirds length of other.

Holotype, male: Mexico (San Luis Potosi), El Salto, about 25 miles west of Antiguo Morelos, July 11-14, 1963, Duckworth and Davis.
Paratype: Same data, 1 ♂.

Chimarra (Curgia) aureopunctata, new species

FIGURES 19-21

The species is related to *C. barrettiae* (Banks) and *C. banksi* (Ulmer) as is shown by the very similar shape of the ninth and tenth segments and the claspers. From both it differs most noticeably in the shape of the eighth tergum, which is divided deeply dorsomesally.

Adult. Length of forewing 6-6.5 mm. Color brown, forewing with many spots of golden hair intermingled with the brown. Male genitalia: Eighth tergum produced ventrolaterally, deeply divided mesally; ventrolaterally produced into a flattened lobe that overlies a narrow, ventral setiferous process. Ninth segment with mesoventral lobe about as broad as long. Cercus about twice as long as broad. Tenth tergum developed into a mesal hood bearing many sensillae. Clasper developed into a dorsal point and a broader ventral lobe. Aedeagus tubular, internally with four short black spines and a pair of interlocking C-shaped sclerites.

Holotype, male: Costa Rica, Turrialba, Feb. 22-28, 1965, Duckworth.

Paratype: Same data, 1 ♂.

Chimarra (Curgia) lobata, new species

FIGURES 22-24

This species also belongs to the *C. barrettiae* group and seems closest to *C. persimilis* Banks, from which it differs in the relatively unmodified eighth tergum, lack of an elongated ventral lobe from the tenth tergum, and the lack of a ventral lip on the aedeagus.

Adult. Length of forewing 6.5 mm. Color in alcohol uniformly pale brown. Male genitalia: Eighth tergum with posterior margin rounded in lateral view, from dorsum with rounded submesal lobes. Ventromesal process of ninth segment about as long as broad. Tenth tergum developed into a narrow hood dorsally and a broader basolateral lobe. Clasper elongate, tapering toward dorsoapical angle. Aedeagus with two short black spines, a slender dark rod, and two C-shaped sclerites.

Holotype, male: Panama, Canal Zone, Rio Agua Salud, Mar. 30, 1965, Duckworth.

Paratype: Same data, 1 ♂.

Chimarra (Curgia) wilsoni, new species

FIGURES 25, 26

This is another member of the *C. barrettiae* group and is probably closest to *C. barrettiae* itself, from which it differs in possessing a pointed tenth tergum and a mesal point on the clasper.

Adult. Length of forewing 7.5 mm. Color brown, legs and antennae slightly paler, head with hairs golden, wings with golden spots intermingled with brown. Male genitalia: Eighth tergum simple, posterior margin slightly projecting, but otherwise unmodified. Ventromesal process of ninth segment terete, longer than broad. Tenth tergum hoodlike, developed into an elongate dorso-mesal point. Clasper almost quadrate in lateral aspect, apicoventral angle slightly developed, and bearing a strong dorsomesal spine. Aedeagus tubular, slightly curved, with a short spine (others broken off?) and a pair of intertwined C-shaped sclerites.

Holotype, male: Costa Rica, Las Cruces near San Vito, Mar. 19-20, 1965, Duckworth.

I take pleasure in dedicating this species to Robert Wilson, on whose property the species was collected and who was very helpful to Donald and Sandra Duckworth during their stay in southern Costa Rica.

PSYCHOMYIIDAE

Polyplectropus macrostylus, new species

FIGURES 27, 28

This species is distantly related to *P. thilus* (Denning), from which it differs in the larger outer lobe of the cercus and the smaller basolateral lobe of the clasper.

Adult. Length of forewing 6 mm. Brown, antennae annulate, forewing with many spots of golden hair. Male genitalia: Ninth segment almost circular in lateral aspect. Tenth segment membranous. Cercus divided into three parts: a thin outer plate slightly longer than broad; a short, broad inner lobe; and a long slender style first directed anteriorly, then curving posteriad. Clasper with an upright basolateral lobe about as high as long, and a long, flat ventral lobe with a short apicodorsal point. Aedeagus short, with ventral lip greatly prolonged, and a stout internal Y-shaped sclerite.

Holotype, male: Costa Rica, Golfito, Apr. 25-28, 1965, Duckworth.

Polycentropus costaricensis, new species

FIGURES 29-32

This species is perhaps closest to *P. picana* Ross, from which it differs greatly in the shape of the claspers and cerci.

Adult. Length of forewing: male 8-9 mm, female 10-12 mm. Color brown, head hairs fuscous, wings brown with many small spots of golden hair. Male genitalia: Anterior margin of ninth segment nearly vertical, posterior margin rounded. Cercus divided into an outer lobe with a slightly differentiated dorsobasal portion and an elongate ventral portion; inner lobe with an enlarged base narrowing to a sturdy, laterally curving process. Clasper somewhat triangular in lateral aspect, with a mesal spine. Aedeagus with apex developed into a trilobed ventral lip, internally with two pairs of short spines, a basal complex of small sclerites, and a pair of apical plates.

Holotype, male: Costa Rica, Mount Poas, May, William Schaus.

Paratypes: Costa Rica, Irazu, 2200-2500 m, May 21-28, 1930, Reimoser, 2 ♂, 6 ♀ (Vienna Museum).

Polycentropus guatemalensis, new species

FIGURE 33

The species is closely related to *P. halidus* Milne, from which it differs most noticeably in the sinuate ventral process of the cercus, which is longer and hooked in *P. halidus*, and the longer and narrower claspers, whose dorsoapical point is displaced slightly basad.

Adult. Length of forewing: male 6-7 mm, female 8 mm. Color dark brown; body and appendages yellow brown, forewings dark brown with numerous spots of golden hair. Male genitalia: Ninth segment with anterior and posterior margins parallel. Cercus with a broad dorsolateral lobe, an elongate, slightly sinuous ventromesal process, and dorsally with an elongate rodlike process. Clasper long and slender, with dorsal margin forming an anteapical point, a sinuate ridge on inner surface culminating in a basomesal spine. Aedeagus with a large apicoventral process, apicodorsally with flat plates, internally with a pair of spines.

Holotype, male: Guatemala (Suchitepequez), Finca Mocá, June 12, 1966, Flint and Ortiz.

Paratypes: Same data, 1 ♂, 1 ♀. Guatemala, Chimaltenango, Aug. 19-20, 1965, Spangler, 1 ♂.

Polycentropus aztecus, new species

FIGURE 34

This species is closest to *P. bartolus* Denning, from which it differs in possessing an arched dorsal process and an apical tooth on the cerci and in having an evenly rounded outline to the clasper.

Adult. Length of forewing 8 mm. Color dark brown; body and appendages slightly paler, forewings with numerous small spots of golden hair. Male genitalia: Ninth segment with anterior margin

rounded. Cercus with dorsolateral lobe continuing evenly into a decurved apical hook and a small ventral lobe; with a short, slightly arched, dorsal process. Clasper short and rounded, with a mesal ridge bearing a sharp tooth near apex. Aedeagus with a sharply decurved apicoventral lip, dorsolateral plates, and many small internal spines.

Holotype, male: Mexico (Michoacan), Insurgente Morelos National Park, east of Morelia, July 14, 1966, Flint and Ortiz.

Paratype: Mexico (Morelos), Cuernavaca, June, collection N. Banks, 1 ♂ (Museum of Comparative Zoology). Mexico (Durango), 10 miles west of El Salto, 9000', June 25, 1964, J. E. H. Martin, 1 ♂; same except July 15, 1 ♂; same except July 28, 1 ♂; same except July 29, 2 ♂; same except August 6, 1 ♂ (Canadian National Collection).

Xiphocentron aureum, new species

FIGURES 35, 36

Closely related to *X. bilimeki* Brauer, this species differs in the elongated bifid apex of the ninth sternum, enlarged apex of the aedeagus, and other small details of the genitalia.

Adult. Length of forewing 8.5 mm. Facial hairs, body, and legs golden; antennae, foretibiae and tarsi, body hairs, and wings fuscous. Hind tibiae slightly enlarged, with a single very large apical spur extending slightly more than half length of basitarsus. Male genitalia: Dorsal bridge of ninth segment narrow, ninth sternum projecting mesally, tip of projection bifid. Tenth tergum broad in lateral aspect, narrow from dorsum. Cercus elongate, in lateral aspect about eight times as long as wide. Clasper bearing a large setal patch mesally, apex narrow and curving dorsomesally. Aedeagus very slender, over twice as long as combined length of ninth segment and cercus, tip enlarged.

Holotype, male: Mexico (Vera Cruz), near Huatusco, July 25-26, 1965, Flint and Ortiz.

HYDROPTILIDAE

Leucotrichia viridis, new species

FIGURES 37-39

This species is related to *L. sarita* Ross although the aedeagus more closely resembles that of *L. pictipes* (Banks). From both it is distinguished easily by the patch of bright green setae on the forewing. The clasper is narrower than in any other described species and the structure of the aedeagus is unique in detail.

Adult. Length of forewing 3 mm. Color grey, antennae with a subapical group of pale segments, face and tegulae with green hairs,

forewings green except for apex. Male genitalia: Seventh sternum with a long spatulate process. Eighth sternum produced laterally, broadly U-shaped ventrally. Ninth segment with a rectangular dorsomesal emargination, posterior margin bordered with a row of long setae. Clasper long and slender, with a dorsal tooth at midlength. Aedeagus membranous at apex, with a pair of dark lateral plates and a ventral scoop; a complex of processes at midlength that bears a pair of basally projecting rods; a simple tubular basal portion.

Holotype, male: Guatemala (Izabal), Las Escobas near Matias de Galvez, Aug. 14–16, 1965, Flint and Ortiz.

Paratypes: Same data, 47 ♂, 4 ♀.

Zumatrichia echinata, new species

FIGURES 40–42

This species is closely related to *Z. galtena* Mosely, from which it differs in lacking digitate lobes apically on the long lateral processes of the claspers and in having a mesoventral spine on the aedeagus.

Adult. Length of forewing 3–3.5 mm. Body and legs brown; antennae darker, with a series of paler segments subapically; head, thorax, and forewings with intermingled patches of greyish-green and black hairs. Male genitalia: Seventh sternum with a pointed mesal process. Eighth sternum with ventral margin almost squarely truncate, with a narrow mesal excision. Ninth segment bearing a row of stout setae dorsally, a process laterally (probably bearing a long seta apically); dorsomesally with a large membranous region with a dorsally projecting lobe, lateral margins heavily sclerotized and bearing posteriorly a forked process that articulates with the lateral sheath of the aedeagus. Clasper digitate in lateral aspect, bearing dorsally a long, heavily sclerotized, sinuous process. Aedeagus with a pair of ovoid lateral sheaths that bear a midventral tooth. Aedeagus proper with a pair of apical spines, a dorsomesal tongue-like strap, lateral sheaths, paired dorsomesal knobs bearing processes, and a complete basal loop.

Holotype, male: Guatemala (El Progreso), San Agustin Acasagustlán, Aug. 11–21, 1965, Flint and Ortiz.

Paratype: Same data, 1 ♀.

Costatrichia panamensis, new species

FIGURES 43–45

This species is closely related to the genotype with which it agrees in the generic characters: reflexed costal cell, enlarged antennal segments, spine of the seventh sternum, and general plan of the

genitalia. It differs strikingly from the type-species, *C. lodora* Mosely, in having a dorsal process from the clasper.

Adult. Length of forewing 2.5 mm. Color in alcohol blackish brown. Male genitalia: Eighth sternum produced beneath ninth segment. Ninth segment with a rectangular dorsomesal emargination, and a short lateral process bearing several long setae. Clasper divided into an elongate, quadrate ventral lobe, and a long tapering dorsal process whose tip meets mesally the tip of the other process. A pair of ovoid plates covering the aedeagus laterally. Aedeagus apically sclerotized and slightly decurved, beneath this a single spine, a pair of plates lateroventrally slightly beyond midlength, a mid-dorsal dome, basal loop large and complete.

Holotype, male: Panama, Canal Zone, Río Agua Salud, Mar. 30, 1965, Duckworth.

Ochrotrichia cruces, new species

FIGURES 46, 47

This species shows some relationship to *O. mono* Ross, from which it is distinguished by the proportionately broader clasper and different structure of the tenth tergum.

Adult. Length of forewing 3.5 mm. Color fuscous, wings mostly denuded, but apparently with some patches of white hair. Male genitalia: Ninth segment rather quadrate laterally, deeply emarginate dorsally. Clasper broadly triangular in lateral aspect, with a ventral row and apical patch of black pegs on mesal face. Tenth tergum complex, with an elongate spine arising dorsomesally curving to right side, a short, black-tipped spine arising slightly beyond, apically with another longer spine, whose tip is directed ventrally, on right side a broad thin plate bearing a short spine mesally.

Holotype, male: Mexico (Mexico), Las Cruces National Park, La Marquesa, 3000 m elevation, July 5-9, 1965, Flint and Ortiz.

Metrichia mexicana, new species

FIGURES 48-51

I am tentatively placing this species in the genus *Metrichia*, to which it will key, although the genital pattern seems quite different. From *M. nigritta* (Banks) it differs in the large lobate tenth tergum and the lack of heavy spines from the aedeagus.

Adult. Length of forewing 2.5 mm. Head and appendages cream colored, tarsi annulate, forewings with large cream-colored patches of hair mixed with fuscous spots. Male genitalia: No processes from sterna. Ninth segment rounded anteriorly. Tenth tergites emerging imperceptibly from ninth segment, cleft mid-dorsally, apices rounded

and bearing a few dark spines. Clasper elongate, with apicoventral angle developed into a process whose tip is upturned. Dorsally an internal U-shaped plate that bears a long narrow process ventrally passing around aedeagus; midventrally with a sinuate indistinct sclerotization. Aedeagus long, apex upturned slightly, with a long tightly appressed process wrapped around stem and another pointed process near end.

Holotype, male: Mexico (Vera Cruz), Río Tacolapan, route 180, km 551, July 25-26, 1966, Flint and Ortiz.

Paratypes: Same data, 2 ♀. Mexico (Vera Cruz), Cuitlahuac, Aug. 10-12, 1964, Spangler, 1 ♂. Guatemala (Suchitepequez), Finca Mocá, June 12, 1966, Flint and Ortiz, 3 ♂, 1 ♀.

Neotrichia costaricensis, new species

FIGURES 52-54

Perhaps most closely related to *N. edalis* Ross, this species seems rather isolated within the genus. The dorsoapical processes of the aedeagus and the hoodlike shape of the tenth tergum are unique.

Adult. Length of forewing 2 mm. Specimens in alcohol uniformly brown. Male genitalia: Eighth segment incomplete ventrally, with anterolateral processes. Ninth segment with anterolateral processes. Tenth tergum hoodlike. Bracteole very indistinct, appearing elongate and enlarged apically in ventral view. Claspers small, black, trianguloid in ventral view. Subgenital plate black, small, and chevron shaped in ventral aspect. Aedeagus slightly moniliform, with a sclerotized apicoventral strap; apex with two pairs of dorsally directed processes, basal process longest with basal teeth, apical process shorter.

Holotype, male: Costa Rica, La Lola near Matina, Mar. 11, 1965, Duckworth.

Paratypes: Same data, 1 ♂; same except May 1, 1957, R. D. Shenefelt, 1 ♂.

Hydroptila veracruzensis, new species

FIGURES 55-57

This species seems to be related to *H. bernerii* Ross, from which it is distinguished by the lateral processes of the ninth segment and the well-developed spiral process of the aedeagus.

Adult. Length of forewing 2 mm. Color in alcohol uniformly brown. Male genitalia: Seventh sternum with a pointed process mesally. Ninth segment with a pointed apicolateral process. Tenth tergite well sclerotized laterally, membranous mesally. Clasper elongate, rounded apically in lateral aspect with a single dark point, in

ventral aspect ribbon-like with tip slightly recurved. Aedeagus with a heavily sclerotized apical portion that is enlarged slightly at neck, spiral process wound around neck one-and-a-quarter turns with apex laying along apical portion, basal portion slender.

Holotype, male: Mexico (Vera Cruz), Cuitlahuac, Aug. 10-12, 1964, Spangler.

Paratype: Mexico (San Luis Potosi), Palitla, June 5, 1966, Flint, 1 ♂.

HYDROPSYCHIDAE

Diplectrona chiapensis, new species

FIGURE 60

This is the first species of the genus found in the New World south of the United States. The male may be recognized immediately by the internal sacs in the seventh segment and the shape of the lobes of the tenth tergites.

Adult. Length of the forewing: male 9-10 mm, female 12 mm. Color pale brown, male with faint dark irrorations on forewings, female with dark marks more distinct. Fifth segment with an anterolateral process that is slightly longer than segment. Male genitalia: Seventh segment with a pair of large striate internal sacs opening on posterior margin. Tenth tergum divided into trianguloid lateral lobes that much surpass the mesal lobe, dorsally completely divided on midline. Clasper long and terete. Aedeagus obliquely truncate apically, subapically with a complex of internal sclerites.

Holotype, male: Mexico (Chiapas), Dolores, route 190, km 1190, Aug. 7, 1965, Flint and Ortiz.

Paratypes: Same data, 5 ♂, 3 ♀.

Hydropsyche vespertina, new species

FIGURES 58, 59

This species is a member of the *H. depravata* group. The combination of dorsal point and rectangular shape of the tenth tergum, moderately angled base and enlarged tip of the aedeagus will separate this species from the other described species of the group.

Adult. Length of forewing 9-11 mm. Brown, antenna with dark V-marks on basal segments, wings marked with typical pattern of golden-brown and grey-brown hairs. Male genitalia: Lateral lobe of ninth segment well developed. Tenth tergum rectangular in lateral aspect, with a sharp apicodorsal point, and a shallow U-shaped dorsomesal excision. Clasper with upper surface of basal segment rather sinuate, apical segment terete. Aedeagus with base angled

at about 135° to axis of stem, tip enlarged, divided into lateral plates.

Holotype, male: Mexico (Michoacan), Tuxpan, July 7-8, 1965, Flint and Ortiz.

Paratypes: Same data, 3 ♂. Mexico (Durango), 11 miles west of El Salto, June 29-30, 1964, Spangler, 1 ♂. Mexico (Michoacan), Turundeo, route 15, km 200, July 14, 1966, Flint and Ortiz, 3 ♂, 1 ♀. Mexico (Michoacan), San Lorenzo, route 15, km 206, July 14-15, 1966, Flint and Ortiz, 4 ♂; same except July 19, 1966, 1 ♂, 1 ♀.

Plectropsyche sandrac, new species

FIGURES 61-63

This is the second species described in the genus *Plectropsyche*. From the type-species, *P. hoogstraali* Ross, it differs in coloration, shape of the tenth tergum, and forked apex of the clasper.

Adult. Length of forewing 7 mm. Color brown, legs paler, wings with many flecks of golden hair. Male genitalia: Ninth segment without a stout hooked process from posterior margin. Tenth tergum with two lateral lobes, basal one flat and flared laterad, and dorsal one terete and upright, apical portion slightly expanded apicoventrally. Clasper with basal segment angulate near midlength, apical segment with a short, dorsal, subapical process. Aedeagus with base inflated, apex with a pair of lateral lobes and a central knob.

Holotype, male: Costa Rica, Golfito, Apr. 25-28, 1965, Duckworth.

I take pleasure in dedicating this species to Sandra Duckworth, who collected this and many other Trichoptera on joint trips with her husband.

Leptonema chila, new species

FIGURES 64-67

This is closely related to *L. salvini* Mosely but differs in the pointed ventral extension of the tenth tergite and the mesodorsal process and lateral spiculate band of the aedeagus.

Adult. Length of forewing 15 mm. Color pale brown. Male genitalia: Tenth tergite with two long dorsal and one dorsomesal processes; laterally a flattened area, expanded ventrally and developed into a sharp tooth. Clasper long, slender, without basomesal processes, apical segment curving mesally and with a pad of black spicules. Aedeagus apically with a pair of basally directed processes along dorsum, tip developed into a pair of short, lateral, winglike lobes, an erect dorsomesal process, laterally with a band of spicules that appears to demark the margin of a flat structure fused to the central tube.

Holotype, male: Mexico (Guerrero), near Chilpancingo, route 95, km 297, July 15-16, 1965, Flint and Ortiz.

Paratypes: Same data, 1 ♂, 2 ♀.

LIMNEPHILIDAE

Limnephilus maya, new species

FIGURES 68-70

The species is perhaps closest to *L. hamifer* Flint, from which it is differentiated immediately by the sharp hook arising from the mesoventral angle of the cercus.

Adult. Length of forewing: male 12-13 mm, female 14-15 mm. Color brownish, wings faintly irrorate, with darker specks along veins. Basal segment of foretarsus in male about one-third length of second segment; forefemur and tibia with a band of dark spicules. Male genitalia: Eighth tergum without apicomesal spiculate lobe. Cercus with a broad dorsolateral lobe, and an erect, dark, hooklike mesoventral process. Tenth tergite low, darkened, developed into a short apicodorsal point. Clasper united to posterior margin of ninth segment, but with a short, quadrate, dorsal prolongation. Aedeagus with lateral arms strongly sclerotized, curved dorsad and ending in a sharp point; central tube with a pair of apicolateral heart-shaped plates and a central beak.

Holotype, male: Guatemala (El Progreso), Finca la Cajeta, Aug. 12, 1965, Flint and Ortiz.

Paratypes: Guatemala, 20 miles northwest of Chimaltenango, Aug. 20, 1965, Spangler, 1 ♂, 1 ♀. Guatemala (Totonicapan), San Cristobal T., June 13, 1966, Flint and Ortiz, 3 ♂. Guatemala, Purulha, July, Schaus and Barnes, 1 ♀. Mexico (Chiapas), San Cristobal las Casas, Aug. 6-8, 1965, Flint and Ortiz, 1 ♂; same except July 17-21, 1964, Spangler, 2 ♀. Mexico (Chiapas), Teopisca, July 9, 1966, Flint and Ortiz, 1 ♂.

LEPTOCERIDAE

Triaenodes anomala, new species

FIGURE 71

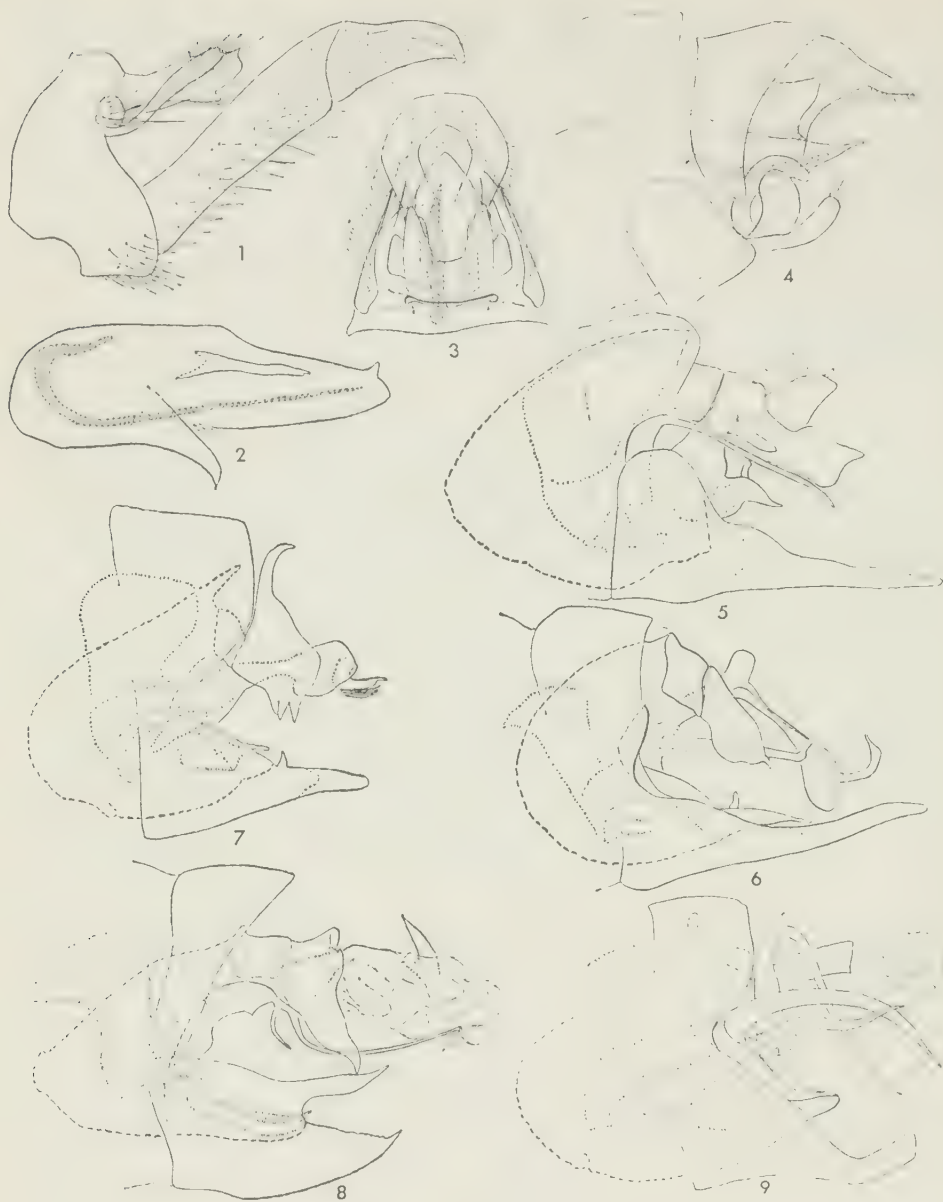
This species is not related obviously to any described North American species of *Triaenodes*. The short, sharply curved basal spine of the clasper, short, pointed tenth tergite, and paired dorsal spines of the aedeagus are all unique.

Adult. Length of forewing 6 mm. Specimens pale brown, but completely denuded. Male genitalia: Ninth segment slightly expanded ventrally, with ventroapical section supporting claspers

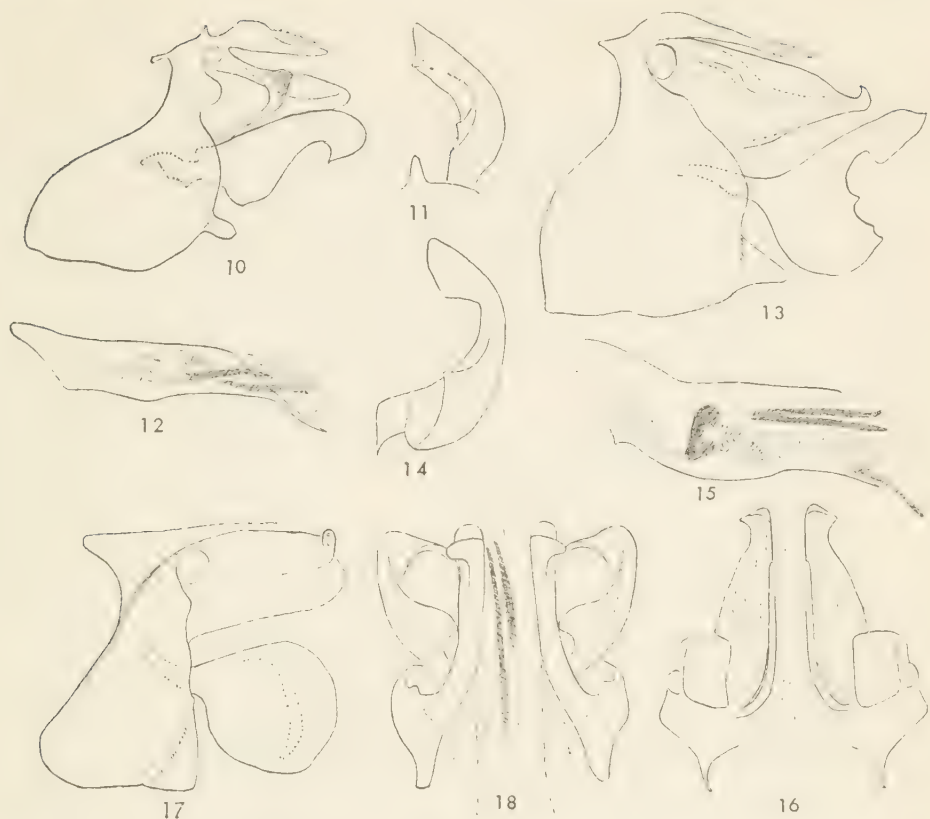
sharply demarked. Cercus short, terete. Tenth tergite pointed, arched over hoodlike dorsal covering of aedeagus. Clasper with a spine-like basal process whose apical half is curved sharply ventrad, a thin dorsal lobe arising from an irregular ridge, apex produced into a sharp point. Aedeagus with a thin, elongate, and pointed ventral part, dorsally two sharply pointed spines, apical halves of all curved sharply ventrad.

Holotype, male: Mexico (Guerrero), near Chilpancingo, route 95, km 297, July 15-16, 1965, Flint and Ortiz.

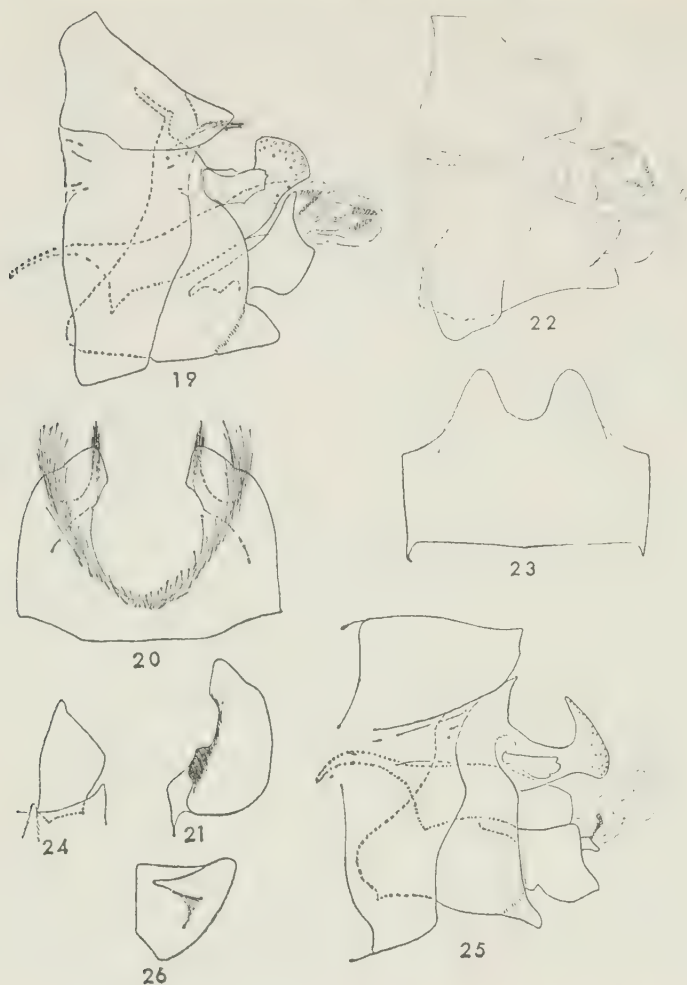
Paratypes: Same data, 2 ♀.



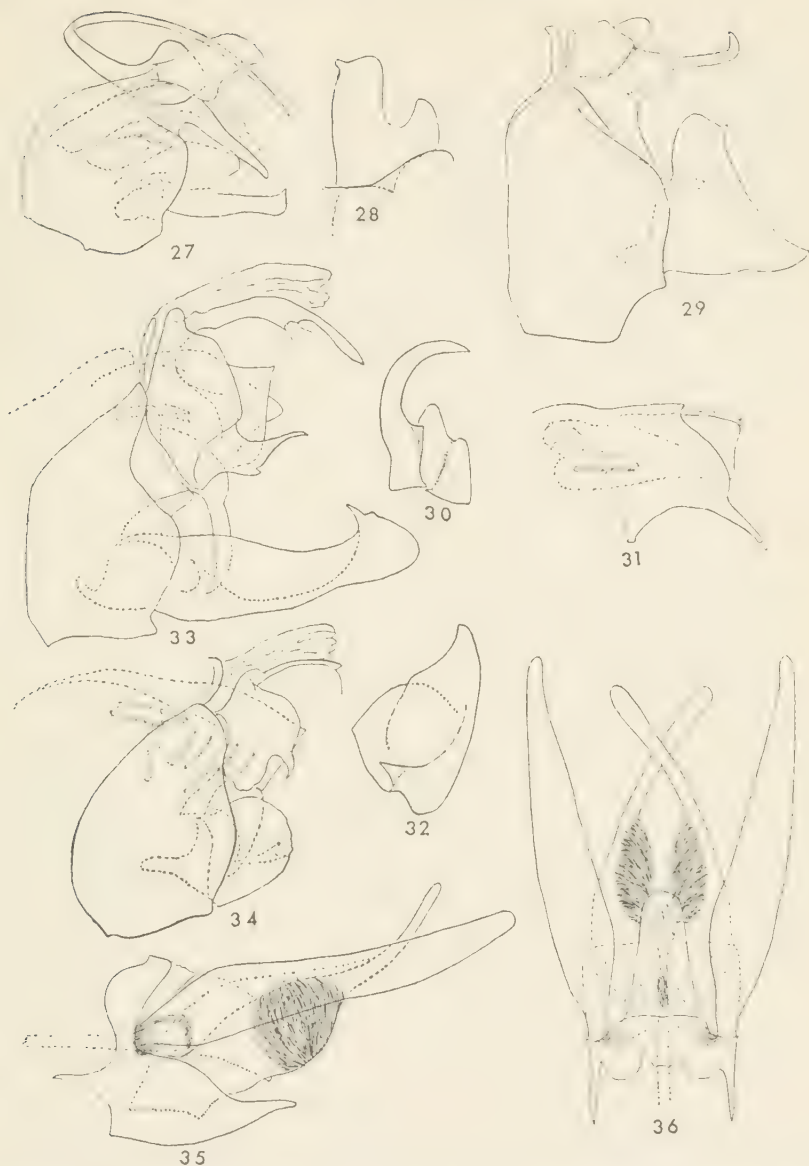
FIGURES 1-9.—*Atopsyche hidalgoi*, new species: 1, genitalia, lateral; 2, aedeagus, lateral. *Culoptila montanensis*, new species: 3, genitalia, posteroventral; 4, genitalia, lateral. *Protoptila laterospina*, new species: 5, genitalia, lateral. *P. marca*, new species: 6, genitalia, lateral. *P. cristata*, new species: 7, genitalia, lateral. *P. huasteca*, new species: 8, genitalia, lateral. *P. spangleri*, new species: 9, genitalia, lateral.



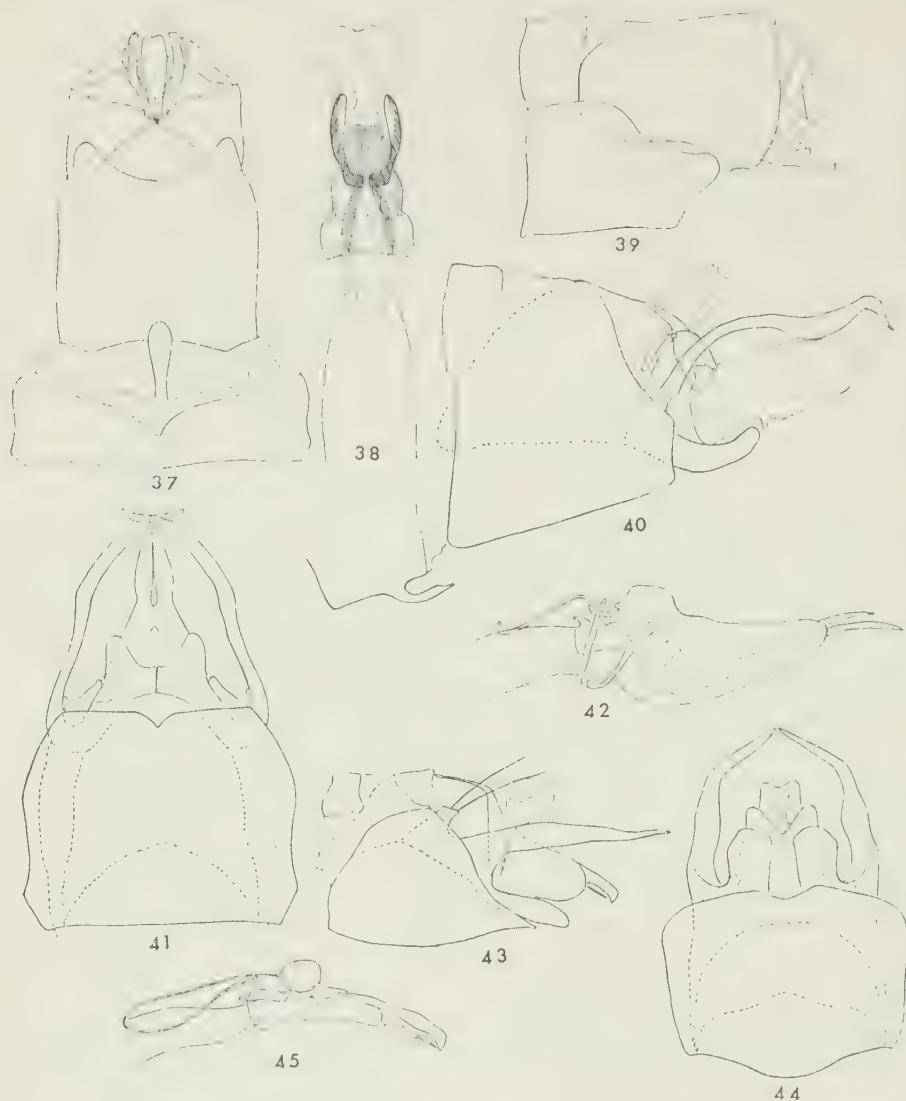
FIGURES 10-18.—*Chimarra duckworthi*, new species: 10, genitalia, lateral; 11, right clasper and ninth sternum, posteroventral; 12, aedeagus, lateral. *C. ortiziana*, new species: 13, genitalia, lateral; 14, clasper, posteroventral; 15, aedeagus, lateral; 16, ninth and tenth terga, dorsal. *C. antigua*, new species: 17, genitalia, lateral; 18, genitalia, dorsal.



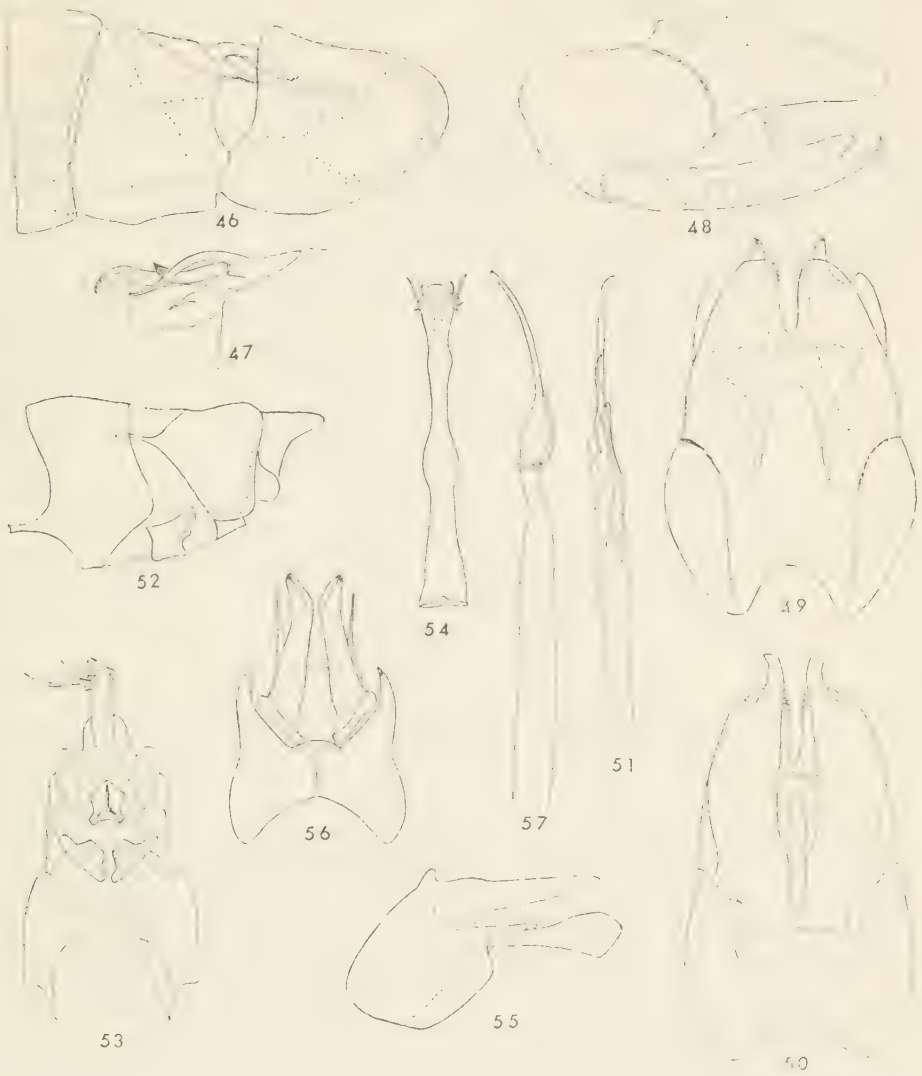
FIGURES 19-26.—*Chimarra aureopunctata*, new species: 19, genitalia, lateral; 20, eighth tergum, dorsal; 21, clasper, posterior. *C. lobata*, new species: 22, genitalia, lateral; 23, eighth tergum, dorsal; 24, clasper and ninth sternum, posteroventral. *C. wilsoni*, new species: 25, genitalia, lateral; 26, clasper, posterior.



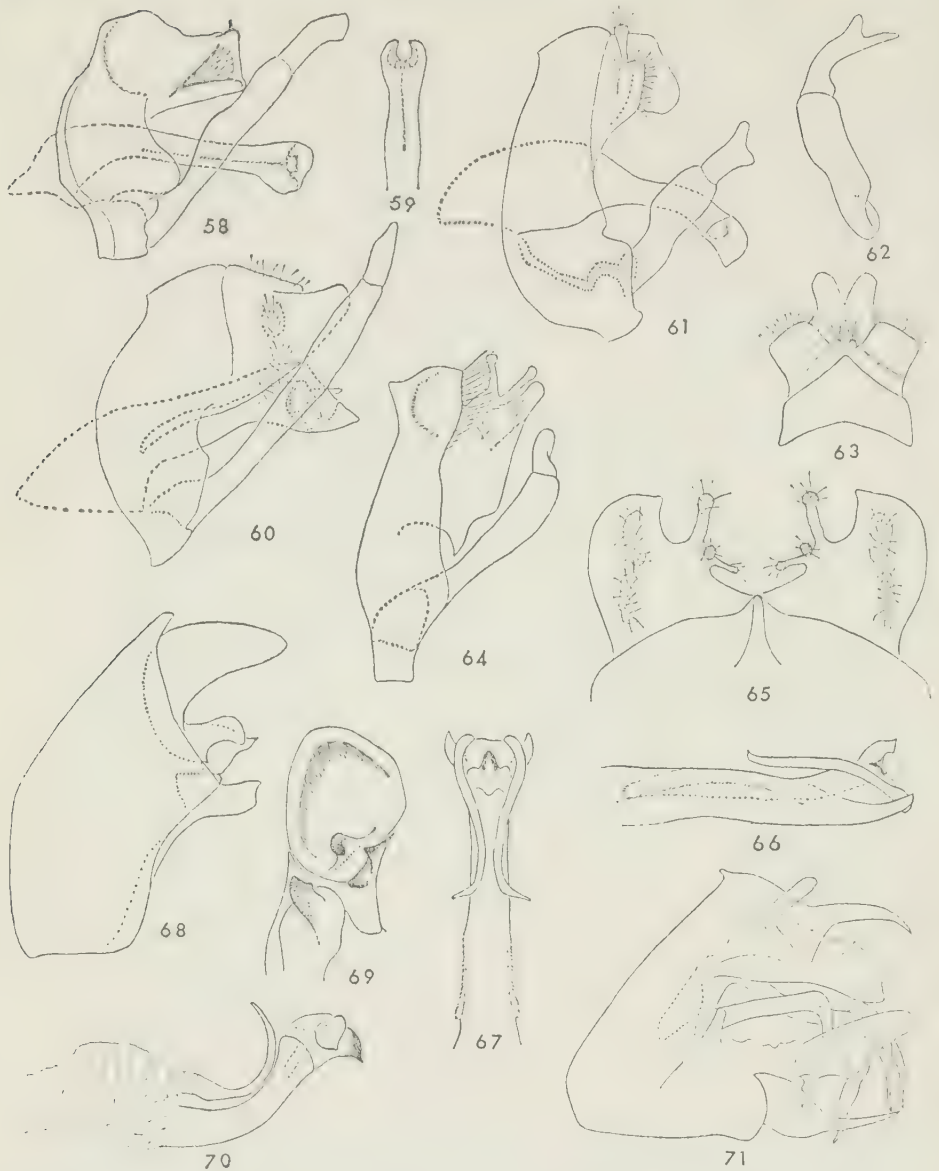
FIGURES 27-36.—*Polyplectropus macrostyla*, new species: 27, genitalia, lateral; 28, clasper and ninth sternum, ventral. *Polycentropus costaricensis*, new species: 29, genitalia, lateral; 30, left cercus, dorsal; 31, aedeagus, lateral; 32, right clasper, posterior. *P. guatemalensis*, new species: 33, genitalia, lateral. *P. aztecus*, new species: 34, genitalia, lateral. *Xiphocentron aureum*, new species: 35, genitalia, lateral; 36, genitalia, dorsal.



FIGURES 37-45.—*Leucotrichia viridis*, new species: 37, genitalia, ventral; 38, aedeagus, dorsal; 39, genitalia, lateral. *Zumatrichia echinata*, new species: 40, genitalia, lateral; 41, genitalia, ventral; 42, aedeagus, lateral. *Cosiatrichia panamensis*, new species: 43, genitalia, lateral; 44, genitalia, ventral; 45, aedeagus, lateral.



FIGURES 46-57.—*Ochrotrichia cruces*, new species: 46, genitalia, lateral; 47, tenth tergum, right side. *Metrichia mexicana*, new species: 48, genitalia, lateral; 49, genitalia, dorsal; 50, genitalia, ventral; 51, aedeagus, lateral. *Neotrichia costaricensis*, new species: 52, genitalia, lateral; 53, genitalia, ventral; 54, aedeagus, dorsal. *Hydroptila veracruzensis*, new species: 55, genitalia, lateral; 56, genitalia, ventral; 57, aedeagus, lateral.



FIGURES 58-71.—*Hydropsyche vespertina*, new species: 58, genitalia, lateral; 59, tip of aedeagus, ventral. *Diplectrona chiapensis*, new species: 60, genitalia, lateral. *Plectropsyche sandrae*, new species: 61, genitalia, lateral; 62, clasper, posteroventral; 63, ninth and tenth terga, dorsal. *Leptonema chila*, new species: 64, genitalia, lateral; 65, ninth and tenth terga, dorsal; 66, tip of aedeagus, lateral; 67, tip of aedeagus, dorsal. *Limnephilus maya*, new species: 68, genitalia, lateral; 69, cercus, tenth tergum, and clasper, posterior; 70, aedeagus, lateral. *Triaenodes anomala*, new species: 71, genitalia, lateral.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3609

An Application of Automatic Data Processing To the Study of Seabirds, I

Numerical Coding ¹

By Warren B. King, George E. Watson, and Patrick J. Gould ²

Seabird distribution, abundance, and movements in the open ocean are difficult to analyze because the limited data available have been collected by various methods, the observers have varied in reliability, and the information is scattered widely. Furthermore, publication of individual sightings, except those of rare vagrants, has been at best spotty with the result that abundance information is difficult to derive from the data. Records of at-sea bird observations are maintained in several institutions in different countries, but most of these are sortable only by hand, an exercise that is extremely time-consuming and invites clerical errors when the data are considerable. As a result, few analyses have been published that involve complicated correlations of extensive distributional and environmental data, and even fewer seabird distribution maps show detailed documentation of seasonal occurrence and abundance.

¹ Contribution no. 22 from the Pacific Ocean Biological Survey Program. A preliminary version of this paper was presented at the 14th International Ornithological Congress, Oxford, England, July 25, 1966.

² King and Gould: Department of Vertebrate Zoology; Watson: Division of Birds.

Smithsonian Institution scientists recorded data on seabirds observed during 15 cruises aboard the Bureau of Commercial Fisheries research vessel *Townsend Cromwell* while the ship was engaged in oceanographic research as a preliminary part of the Trade Wind Zone Oceanography Program. These data have been utilized in a pilot study to determine the feasibility of recording, storing, and analyzing seabird records in a computerized automatic data processing system. The system described herein is in part descended from a simpler one developed by the Bureau to store and analyze its own bird observations. Coding used in the various fields of data in this pilot project is presented in this paper and details of the codes are given in the tables. Computer programming for the system is discussed by Creighton (in prep.). A full report on the results of the analysis of bird observation data from these cruises will be published by King, but the preliminary results suggest that ADP may be applicable to a cooperative international system of seabird observation, data storage, and analysis.

The Bureau of Commercial Fisheries, Hawaiian Island area, has been a vital partner in the development of this pilot study. John C. Marr, area director and Gunter Seckel, coordinator of the Trade Wind Zone Oceanography Program, and their staff have made it possible for Smithsonian scientists to observe seabirds aboard the *Townsend Cromwell* and have given us access to BCF oceanographic data, punch cards, and computer programs. Reginald Creighton's close cooperation as programming analyst has turned the projected aims of this system into a working reality. The original impetus to undertake the computer analysis of the seabird observation data came from Philip S. Humphrey, Principal Investigator, Pacific Ocean Biological Survey Program. Nicholas J. Suszynski, Jr., Director of the Information Systems Division at the Smithsonian, provided valuable advice. Mrs. Anne Keenan Poulson patiently prepared the figures for this publication. We are deeply grateful to all of them.

OBSERVATIONS.—From March 1964 to July 1965 the Smithsonian Institution conducted an at-sea study to determine the distribution, movements, and abundance of seabirds in a 500,000-square-mile area of the central Pacific Ocean south and east of the main Hawaiian Islands between 148° and 158° west longitude and 10° and 26°30' north latitude (fig. 1). Each of the 15 replicate cruises covered a fixed track of 4460 miles and lasted approximately 20 days. There was no cruise in August 1964.

Two experienced observers alternated 2-hour watches each day from sunrise to sunset. They identified birds at sea as accurately and specifically as possible and recorded all data on standardized reporting forms. Some identifications were confirmed through collection of

specimens. The time of observation was recorded to the nearest minute. Whenever possible, an actual count was made but large flocks were only estimated within accuracy limits. The direction of movement, if any, was recorded. Notes were made on behavior, plumage, molt, age, sex, and any other data that appeared significant. Descriptions were recorded in cases of uncertain identification. Standard marine meteorological observations were taken every six hours. Bureau of Commercial Fisheries personnel took bathythermographs and recorded weather conditions every one-half degree, hydrographic stations every one and one-half degrees, and surface plankton tows every evening. Ship's position was reckoned hourly and early morn-

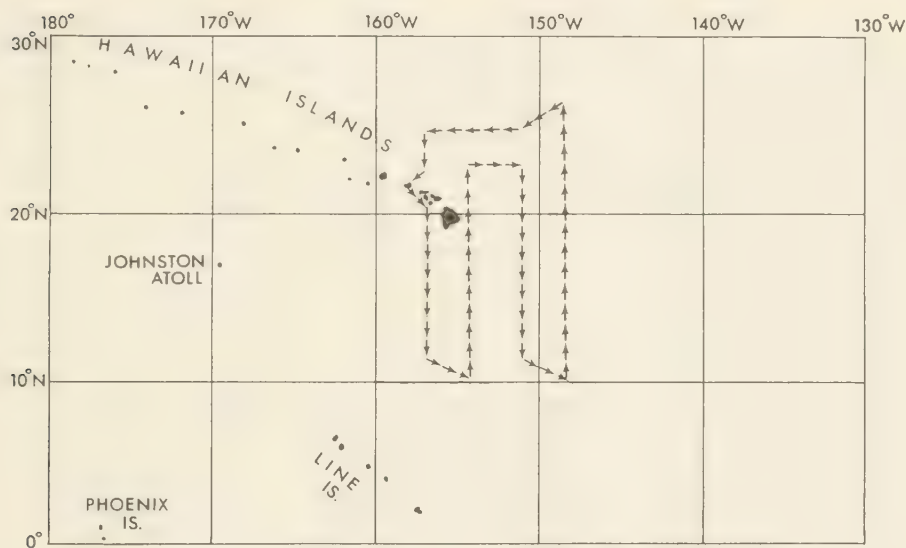


FIGURE 1.—Replicate track in central Pacific Ocean followed during 15 monthly cruises of the *Townsend Cromwell*.

ing; midday and evening celestial or LORAN fixes were taken, conditions permitting.

During the 15 months of the study, 13,080 sightings of 65,707 birds were made in 3561.1 hours of observation covering 34,384 linear miles.

Coding

The quantity and complexity of data accumulated necessitated use of an automatic data processing system for rapid and accurate sorting, compilation of tables, and the plotting of distribution and density charts. In addition, ADP made possible a sophisticated analysis of the effects of many environmental factors, both oceanographic and

meteorologic, upon the distribution and movements of seabirds in the area. And finally, ADP permitted more rapid statistical handling of the data in order to ascertain (1) whether apparent monthly population and distribution changes were real or were merely due to inadequate sampling, and (2) whether or not apparent correlations between environmental factors and bird distribution were statistically significant.

The large number of different parameters to be analyzed required the use of three decks of 80-column punch cards to retain a maximum amount of data in the system. The three decks were called "sighting deck," code number 99, "environment deck," 03, and "day deck," 98 (fig. 2). Of the three decks, the sighting deck was the largest, con-

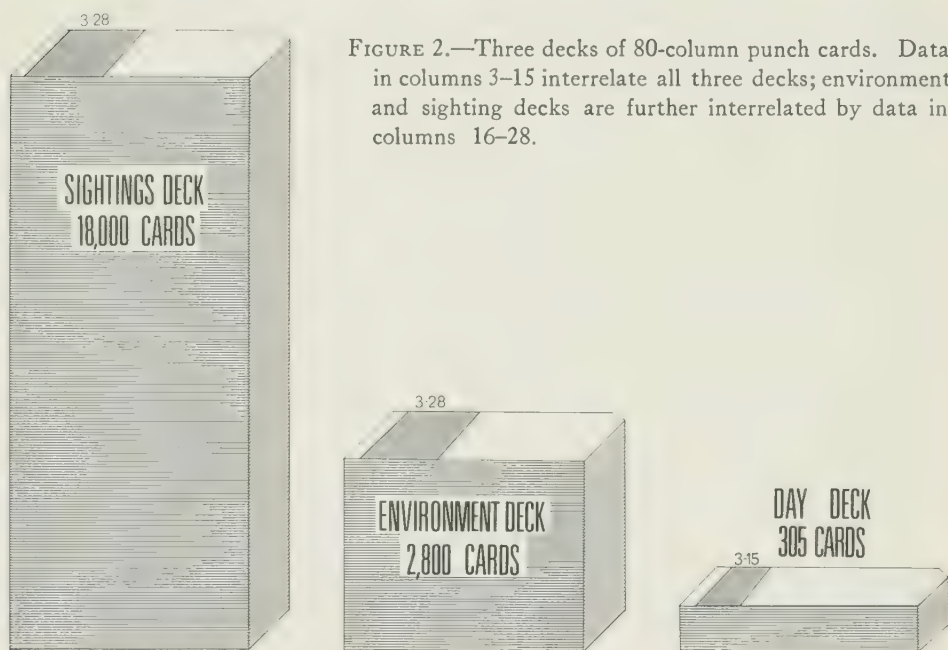


FIGURE 2.—Three decks of 80-column punch cards. Data in columns 3–15 interrelate all three decks; environment and sighting decks are further interrelated by data in columns 16–28.

taining 18,000 cards for the 13,080 sightings. The environment deck was smaller, containing 2800 cards. Each environment card was associated with all the sightings from the time of one set of environmental data observations to the time of the succeeding set of observations. Similarly, each of the 305 day cards was associated with all sightings and all environment cards on that day. Thus, each observation had a sighting card or cards, an environment card, and a day card. But it shared the environment and day cards with other sightings.

The three decks of cards were tied together by common data consisting of ship's name, cruise number, and date. The environment and sighting cards were further linked by hour and position.

The 80-column punch card system works on a numerical code into which all verbal data recorded by the observer at sea must be translated before entry. The *Cromwell* observations, oceanography, weather, and ship's position were checked for accuracy by a single editor and entered as numbers on intermediate coded sheets of different key colors. Data were punched on the cards directly from the intermediate coded sheets.

SIGHTING DECK.—The sighting card includes all data that pertain to each individual sighting. We define a sighting as the observation of a bird or group of birds acting as a unit. Data for the following fields were entered in the indicated columns on the green intermediate sheets (fig. 3) for the sighting cards (card code 99 in columns 1–2):

Ship name 3–5	Color-plumage phase 49
Cruise number 6–9	Molt 50
Date 10–15	Whether or not a specimen was collected 51
Local time 16–19	Food association 52
Position 20–28	Special weather conditions 53
Species identification 29–34	Special information 54
Association code 35	Duration of sighting (minutes) 55–57
Species identification reliability 36	Ship's speed (knots) 58–59
Number 37–41	Ship's direction 60–61
Number reliability 42	Distance to nearest land (nautical miles) 62–65
Direction of bird movement 43	Distance to nearest breeding area (nautical miles) 66–69
Behavior 44	[Columns 70–80 were not utilized on the sighting cards for this program.]
Color marking 45	
Method of marking 46	
Age 47	
Sex 48	

Each ship used for observations was assigned a code number; the *Cromwell* was 006. Cruises were coded serially for each ship. The date was expressed as month, day, and year with only the final two digits being coded for year. Local and all other absolute times were expressed to the nearest minute in the 24-hour system.

Position of the sighting and all other localities were expressed as coordinates of longitude and latitude. In order to economize on columns, the world was divided into octants along the equator and each 90° meridian. The octants (column 20) were numbered from 0–3 in the Northern Hemisphere and from 5–8 in the Southern Hemisphere beginning at 0°–89°59'W and proceeding west. In this way it was not necessary to express the 100's figure and east and west for longitude nor north and south for latitude.

The numerical code for seabird species is based on a revised checklist of the seabirds of the world. It is designed to permit data retrieval hierarchically by class, order, family, genus, species, and/or subspecies. The code requires only six digits because of the relatively

Sightings Card										Ship				Cruise				Date																																									
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15																															
Hour	O	Latitude	Longitude	Identification	A	R	Numbers	Nr	M	B	C	T	A	S	CP	M	C	F	W	S	Sight	S	S	P	S	Di.	Di.	to	Land	Di.	to	Br.																											
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75

Environment Card										Ship				Cruise				Month				Year																																									
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15																																			
Day	Hour	O	Latitude	Longitude	B. T.	Thermoc	Sur. Tem.	Sur. Sal.	10	M.	W. Dir.	W. SP	Bor.	W	S	V	Sur. Ox.	Sur. Phos.	M	C	Air	T	Rel. H.	W. Dir.																																							
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75

Day Card										Ship				Cruise				Month				Year																																									
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15																																			
Day	Hour	H.	Dir.	M.	Noct.	Mi.	O	MN	Lat.	MN	Long.	S	R	Lat.	S	R	Long.	S	S	R	T	SS	T	O	Plank.																																						
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75

Day										Ship				Cruise				Month				Year																																									
1		2		3		4		5		6		7		8		9		10		11		12		13		14		15																																			
Day	Hour	H.	Dir.	M.	Noct.	Mi.	O	MN	Lat.	MN	Long.	S	R	Lat.	S	R	Long.	S	S	R	T	SS	T	O	Plankton	Begin	Obs.	End	Obs.	S.P.A.																																	
12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75

FIGURE 3.—The three intermediate coded sheets used in pilot project and revised format of the intermediate coded sheet for day deck.

low number of forms involved, yet it includes all known taxa of sea-birds and has sufficient leeway for most synonymy and the inclusion of land-based accidentals, migrants, and marine mammals and reptiles. The first digit represents class; the second, order; the third, family; the fourth, genus; and the fifth and sixth, species or field-recognizable, nonoverlapping subspecies. The code for central Pacific Ocean birds used in this pilot program is given in table 1. Codes for seabirds (presently being revised) and marine mammals of the world are available from the Smithsonian Institution. Birds that are identifiable only to class, order, family, genus, and/or species may be entered and retrieved at the same level of reliable identification.

When the code translation of a single sighting involves more than one item of information in any category, additional sighting cards are needed for complete and unique expression. Thus, a complex sighting involving four species of birds of three color phases and of three age categories requires 10 cards. These 10 cards are tied together by their identical times and by a special code key known as the association key. A "0" in the association column (35) indicates a simple sighting expressible by one card. A "1" in the column indicates that the card has information pertaining to the same sighting as all other cards with the same time and a "1" in the association column. A sighting of a mixed flock of sooty terns and brown noddies feeding together would be represented by two cards each bearing a "1" association code number. When two or more cards of a sighting have identical data in the ship, cruise, date, time, position, species, and number fields but differ in other fields such as age or behavior, then the numbers 2, 3, 4, or 5 are used in the association column to preserve uniqueness. This is necessary because the computer automatically rejects, as duplicates, cards with identical data in columns 1-42. If a sighting involves two sooty terns, one adult and one immature, the first card bears the association number 1 and the second, number 2. A sighting of three sooty terns, one feeding, one sitting on the water, and a third searching, would have three cards with association code numbers 1, 2, and 3 respectively. If, on the other hand, two or more different sightings have identical data in the ship, cruise, date, time, position, species, and number fields but the birds were not associated in the same flock, we employ the numbers 6, 7, 8, 9, or 0 in the code to indicate uniqueness but nonassociation.

Note that "0" in the association code has a double function. It may be used merely to denote a simple, one-card sighting or one of five concurrent nonassociated sightings. When more than five nonassociated sightings occurred simultaneously, it was necessary to adjust the time of the supernumerary sightings by one minute to preserve uniqueness.

Codes for species identification and number reliability, direction of bird movement, behavior, marking, and other sighting fields are given in table 2. Reliability was determined and recorded by the observer in his at-sea notes. Some of the at-sea logs recorded doubtful identifications of dark shearwaters as "sooty-slender-bill" with a notation that the underwings appeared light. Such sightings were coded as "sooty shearwaters," 122519, in the species identification field (29-34), as "either this or the next most similar form," 2, in the species reliability field (36) and as [consult] "identification" [data in at-sea log], 1, in the special information field (54). The next similar species to the sooty shearwater in the central Pacific is the slender-billed shearwater, but in the southern Atlantic Ocean it might be the great-winged petrel, *Pterodroma macroptera*.

Special means of marking birds to show points of origin or other status were employed in studies of seabirds in the central Pacific Ocean. Birds marked by "painting" with body dye or by attaching leg bands and colored plastic streamers were expressed in code in the system. Colors were used for identification of birds at a distance when they could not be captured. In seabirds, color or plumage phases may indicate geographic origin or reproductive condition. Light and dark color phases in petrels, boobies, and jaegers may vary in relative proportions in different geographic populations. A pinkish or yellowish tinge in white tropicbird, gull, or tern plumage may indicate reproductive activity.

The special weather conditions field was used to refer to squalls, storms, or calms that were so local they could not be expressed in the environment deck. The special information column was used as a warning signal to alert the scientist to consult the raw data for a particular field in the observer's at-sea log. A routine sighting as a bird crossed the ship's bow was considered arbitrarily to have a duration of one minute. Birds following in the wake were counted periodically, and an attempt was made to determine duration of their association with the ship. Direction of ship movement and wind and wave directions on the environment card were recorded as the first two digits of the compass heading rounded off to the nearest 10 degrees (e.g., $165^{\circ}=17$, $24^{\circ}=02$). A stationary ship or calm air or sea was coded 00.

Part of a page of an at-sea observation log and its numerically coded translation onto the intermediate coded sighting sheet is shown ready for punching into cards in figure 4.

ENVIRONMENT DECK.—The format of the environment card was slightly modified from cards already in use by the Bureau of Commercial Fisheries in the Hawaii area. Complete environmental data of this sort are recorded on standard forms and punched into cards

on file at the BCF in Honolulu. The utilization of this existing card format in our system saved duplication of effort and man hours of work by permitting standardization of data collection and storage. The codes used by the BCF and by us in this program are based on number codes developed by the Hydrographic Office in Publication 607, "Instruction Manual for Oceanographic Observations," 1955, reprinted 1959, for use by deck officers of vessels. On the environmental punch card deck (code 03 in columns 1-2), the fields for ship's

Ship Direction

SMITHSONIAN INSTITUTION
DIVISION OF BIRDS
AT SEA DAILY LOG - E

SPECIMEN
or

OBSERVERS:
P. Gould
W. King

Date 18 Oct. 60
Pg. #

TIME	SPECIES	#	DIR.	BAND NO.	REMARKS
0615	Sooty Tern	20			Feeding, all adults
0617	Wedgetail	1	N		light phase
0625	Red-footed Booby	4			Adult light phase
	Broad-Billed Grapto	1			Adult
	Sooty Tern	100 ± 10			feeding, tuna seen

Sightings Card

Ship

Cruise

Date

1 2		3 4 5		6 7 8 9				10 11 12 13 14 15				
99		006		0012				101866				

Hour	Lat	Long	Identification	A	R	Numbers	N	M	B	C	T	A	S	C	M	C	F	W	S	Sight	SS	SD
0615	1201857	0114686	70000000	00	00	00000000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1218	
0617	1201857	0114225	10000000	00	00	00000000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1218	
0625	1201657	0113321	1310000000	00	00	00400300	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1218	
0625	1201657	0113610	7100000000	00	00	00000000	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1218	
0625	1201657	0114686	71000100	00	00	0020300	00	00	00	00	00	00	00	00	00	00	00	00	00	00	1218	

FIGURE 4.—Bird observation data in at-sea log (above) and part of the numerical translation onto the intermediate coded sheet for sighting deck.

name 3-5, cruise number 6-9, date 10-15, time 16-19, and position 20-28 provide linkage with a particular group of sighting cards. The following additional fields of data are found on the environment card and are coded on red intermediate sheets (fig. 3) in a manner analogous to that used for the sighting deck.

Bathythermograph file number for
reference 29-31

Thermocline depth 32-34

Surface water temperature 35-37

Surface salinity 38-40

Water temperature at 10 meters 41-43

Wind direction 44-45
 Wind speed 46-47
 Barometer 48-49
 Weather conditions 50-51
 State of sea 52
 Visibility 53
 Surface oxygen 54-56
 Surface phosphate 57-59

Moon age 60
 Cloud cover 61
 Air temperature 62-64
 Relative humidity 65-66
 Wave direction 67-68
 [Columns 69-80 were not utilized on the environment cards.]

Thermocline depth was recorded in meters. Water temperatures at the surface and at 10 meters and air temperature were given to the nearest .1° C. Surface salinity was recorded in parts per thousand, omitting the initial 3 for any value. Wind and wave direction were coded in the same manner as direction of ship's movement, column 43 on the sighting card. The code for weather conditions is given in table 3 and those for state of sea, visibility, and cloud cover, in table 4. Wind speed was recorded in knots. Barometric pressure was recorded as the last two digits of a millibar reading, e.g., 1015 millibars was coded as 15. Surface oxygen was recorded in milliliters per liter to the nearest .01 and surface phosphate in microgram atoms per liter to the nearest .01. Relative humidity was expressed in whole percent. Moon age was not recorded for this study but a BCF code is given in table 4.

DAY DECK.—The day card includes information pertaining to all sighting and environment cards for one day and is concerned mainly with positions, distances, and times. From this card, in combination with the sighting cards from the entire day, the computer calculates daily density figures in terms of birds per hour and birds per linear mile. Through the use of such density figures, we can make direct comparison between bird density in different areas of the ocean and from day to day, month to month, and even year to year within the same area. It is important to be able to express density as a factor both of time and distance because the two are not correlated necessarily on a cruise with periodic stops such as the BCF *Cromwell* cruises. The day cards, code 98 in columns 1-2, are linked to the other two decks through information on the ship's name 3-5, cruise number 6-9, and date 10-15. In addition, the day card contains the following information coded on the blue intermediate sheets (fig. 3):

Diurnal hours of observation 16-18
 Diurnal miles of observation 19-21
 Nocturnal hours of observation 22-24
 Nocturnal miles of observation 25-27
 Position at midday 28-36
 Position at sunrise 37-44
 Position at sunset 45-52

Local time of sunrise 53-56
 Local time of sunset 57-60
 Number of observers on each watch 61
 Quantitative plankton analysis 62-64
 [Columns 65-80 were not utilized on the day cards.]

Hours and miles of observations were recorded to the nearest .1 hour and whole mile respectively. The ship's location at noon was recorded as midday position for a full day of observations but the midpoint of the diurnal track was recorded for a partial day of observation. Surface plankton was collected in a 25-minute tow with a 1 meter .308 millimeter terminal mesh net. Volume was measured by BCF personnel and recorded in cubic centimeters per cubic meter of water strained.

Computer Analysis

The coded information was transferred from the cards onto magnetic tape in the computer with the result that all data pertinent to each sighting were stored and printed out as a unit. Thus, environmental data and the raw materials for calculating densities were included with the print-out for any individual sighting.

The system has been programmed in COBOL [Common Oriented Business Language] for a General Electric 425 digital computer having 128,000 characters of core storage.

The data flow sheet for the system thus includes the sighting that is recorded in the observer's field notes, edited and coded on the intermediate sheets, punched into the cards, and transferred onto tape in the computer where it is available for print-out, plot-out, and analysis (fig. 5).

With this information fed into the system, various questions may be asked of the data. The simplest questions are descriptive: what species occur in what numbers, where, and when? We can ask for a detailed print-out of all the data for all sightings arranged by species, by locality, or by time. Part of such a code print-out of red-footed booby observations is shown in figure 6.

Relatively simple correlations of species distribution with environmental conditions may be requested as tallies to provide raw materials for graphs or statistical analysis. Tallies of black-footed albatross and sooty tern sightings at various surface water temperatures yield data for plotting bar graphs (fig. 7). The two species differ somewhat in water temperature preference.

More detailed compound questions involving several conditional clauses will give more restricted print-outs; thus, by asking for all records of sooty terns in aggregations greater than 25 seen feeding within the first two hours after sunrise during May in association with water 25°–27° C and having a salinity greater than 34.5 parts per thousand we obtain a much more selective listing. Indeed, only one sighting qualified (fig. 8). The instructions are in COBOL code language, which the computer understands. Asking this question of our 13,080

sightings took 20 minutes of computer time. Twenty-five questions of this complexity may be asked at the same time.

The most graphic application of automatic data processing to the observation data is for plotting distribution maps. Seasonal movements and changes in abundance may be depicted directly by machine print-outs in the form of annotated cruise tracks. Such machine printed distribution maps of the two color phases of wedge-tailed shearwaters from May to July are shown in figure 9. Light phase birds breed in the Hawaiian Islands to the north; dark phase birds, below

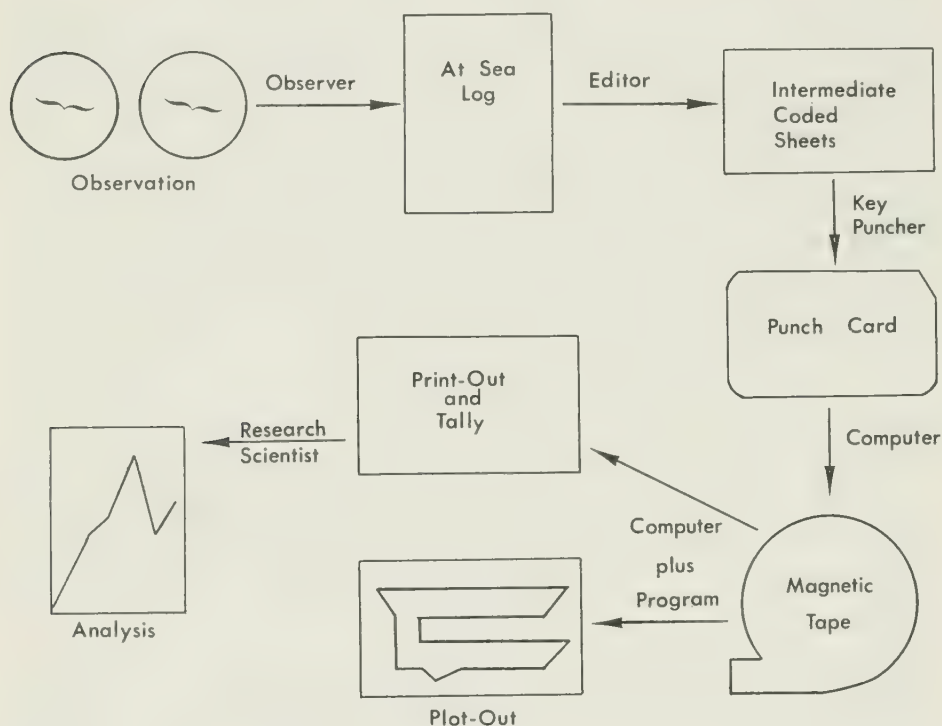


FIGURE 5.—Data flow chart for seabird ADP system.

the equator to the south. Density distribution maps of this sort may be requested to show actual numbers of birds observed as in figure 9 or rates of occurrence in birds per mile or per hour.

Worldwide Application

Because this ADP system was intended primarily to handle data obtained on this one set of cruises in the central Pacific Ocean, some modifications will be necessary in order to analyze data from elsewhere in the Pacific or in other oceans of the world. Some of these modifications already have been incorporated into the Smithsonian program;

others are suggested only for possible incorporation into a larger scale international program.

On the sighting cards (p. 5), the fields "distance to nearest land" (columns 62-65) and "distance to nearest breeding colony" (66-69) will be deleted. These distances have proved laborious to calculate but will be provided automatically by the computer when the necessary program has been written. It may be possible to incorporate a fourth deck of cards into the system that will give the phenology of

DATE	TIME	OCTANT	LATITUDE	LONGITUDE	SPECIES	A.R.	NUMBER	N-RELIAB.	S-R LATITUDE	S-R LONGITUDE	S-R TIME	HRS. AFTER S-R	HRS. BEFORE S-R	DI. TO LAND					
640316	1625	1	2101	5742	133213	10	0000001	0	2117	5757	0640	10	00	0050					
14	12	1	2100	5740			0000001	7	2044	5723	1836	00	03	0050					
640316	1625	1	2101	5742	133213	20	0000001	0	2117	5757	0640	10	00	0050					
14	12	1	2100	5740			0000001	7	2044	5723	1836	00	03	0050					
640316	1629	1	2101	5742	133213	00	0000001	0	2117	5757	0640	10	00	0050					
14	12	1	2100	5740			0000001	7	2044	5723	1836	00	03	0050					
DIR. SHIP	SHIP SPEED	NO. OBS.	OCTANT	M-N LATITUDE	M-N LONGITUDE	NO. OF SIGHT.	COMPLETENESS	SS. LATITUDE	SS. LONGITUDE	SS. TIME	HRS. AFTER SS	HRS. BEFORE SS	DI. TO BREED.						
041	050	001	245	000	0903	18	001	66	2	9	1	2	3	0	0	0002	1		
000	039	031	512	000	241	02	242	00	0	0	0	0	0	0	1	000	006	2	
041	050	001	245	000	0903	18	001	66	2	9	1	2	3	0	0	0002	1		
000	039	031	512	000	241	02	242	00	0	0	0	0	0	0	3	000	006	2	
041	050	001	245	000	0903	18	001	66	2	9	1	2	3	0	0	0002	1		
000	039	031	512	000	241	02	242	00	0	0	0	0	0	0	0	000	006	2	
NOCT. HRS.	NOCT. MILES	THERMOCLINE	SALINITY	PHOSPHATE	TO M.	WEATHER	AIR TEMP.	WAVE DIR.	COLLECTED	FOOD ASSOC.	WEATHER	SPECIAL	MOLT	C. PHASE	SEX	AGE	PLANKTON	SHIP NO.	LINE NO.

FIGURE 6.—Part of a data print-out of records of red-footed boobies seen on *Cromwell* cruises.

breeding in individual colonies of seabirds in order that distribution may be compared directly with breeding schedule.

On the environment card, "relative humidity" (65-66) will be replaced by "dew point" or "depression of wet bulb air temperature under dry bulb." At sea, either of the latter two readings would give a more meaningful indication of the moisture content of the air than relative humidity.

Clarity of water may be an important factor in the feeding of seabirds that search for food visually from the air. Depth of visibility

of a Secchi disc provides a good absolute measure for water clarity and one that is taken easily as a routine oceanographic measurement. At the same time, apparent water color may be recorded in the Forel scale. The BCF records and files both measurements on their punch cards. Photometric depth is another measure of water clarity made on oceanographic cruises, but it demands much more complicated instrumentation and the figures vary with intensity of illumination. It may be useful to record the presence of flotsam, large masses of weed, ice, or other floating debris. Some observations suggest that marine life and birds may be attracted locally to foreign matter in the water.

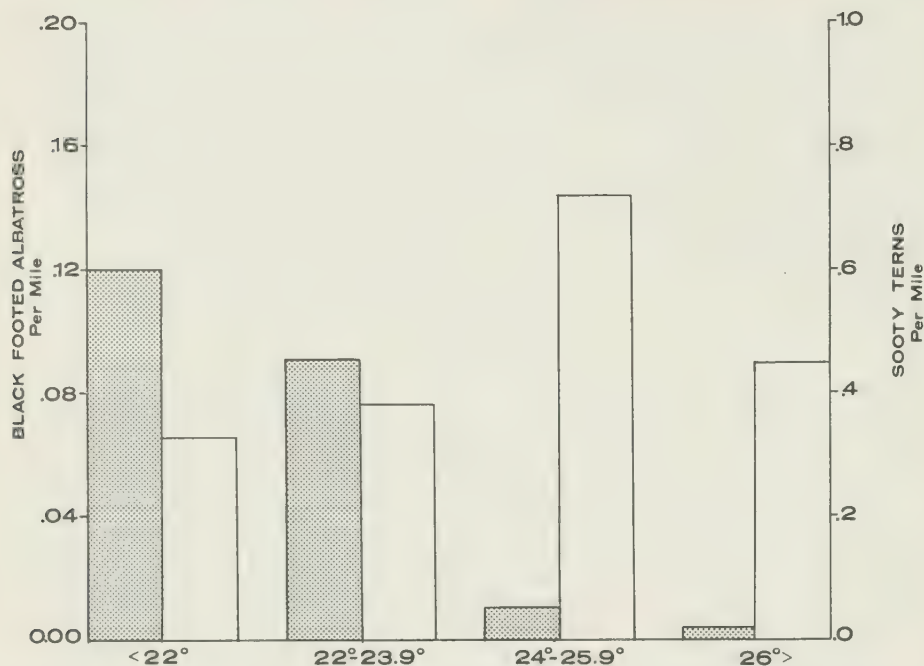


FIGURE 7.—Bar graphs of abundance of black-footed albatross (shaded) and sooty terns (white) in birds per mile seen at various surface water temperatures on *Cromwell* cruises.

On the day sheets several changes should be made. All observations for the pilot program were made in a single octant of the world, but other sets of observations may be made in several octants or a cruise track may cross the equator or a 90° meridian and thus require two octant codes for the same day. For this reason octant columns (37 and 46) should be added to sunrise position and sunset position fields. As a result, the fields for sunrise and sunset time and number of observers would be moved two columns to the right. It has not been feasible to make these octant additions in the Smithsonian program.

Three additional fields have already been added to the day sheets: time of beginning of observations (65–68), time of end of observations (69–72), and special parametric analysis (73–75). The times of beginning and end of observations coincided with the times of sunset and sunrise on the *Cromwell* cruises, but in other studies observations may begin or end earlier or later.

In the pilot study, density figures were computed on the basis of a full day's observations. In future studies, however, it may be necessary to determine abundance in areas that were covered in less

PROVIDE ALL RECORDS OF SOOTY TERNS IN AGGREGATIONS GREATER THAN 25 SEEN FEEDING WITHIN THE FIRST TWO HOURS AFTER SUNRISE DURING MAY IN ASSOCIATION WITH WATER 25 TO 27 DEGREES C AND HAVING A SALINITY GREATER THAN 34.50 PARTS PER THOUSAND.

REQUEST PARAMETER CARDS, PACIFIC PROJECT, JUNE 8, 1966.

IF IDENT EQUALS 146867 ,
 AND NUMB IS GREATER THAN 00025 ,
 AND HOURS-AFTER-SUNRISE IS GREATER THAN 00
 AND LESS THAN 03 ,
 AND BEHAVIOR EQUALS 3 ,
 AND WATER-TEMPERATURE IS GREATER THAN 249
 AND LESS THAN 271 ,
 AND SURFACE-SALINITY IS GREATER THAN 450 ,
 AND MONTH EQUALS 05 ,
 GO TO SR01.

DATE	TIME	SPECIES	NUMBER	HOURS AFTER SUNRISE	SURFACE TEMP	SURFACE SALINITY
05-29-64	0630	Sooty Tern	40	2	26.2°	34.6‰

FIGURE 8.—Complex conditional question, its COBOL translation, and answer concerning sooty tern observations on *Cromwell* cruises.

than a full day. The new special parametric analysis (SPA) field will be introduced on the revised day card for that purpose. An entry in this field will “flag” for restricted abundance analysis all observations made within the time segment represented on the day card. The use of all combinations of punches in each column (10 digits and 26 letters) permits designation of 36^3 (46,656) different areas.

On the day card the number of hours of observation, the actual times of observation, and the distance travelled within the designated area must be fractionized by entering them on two or more “fractional”

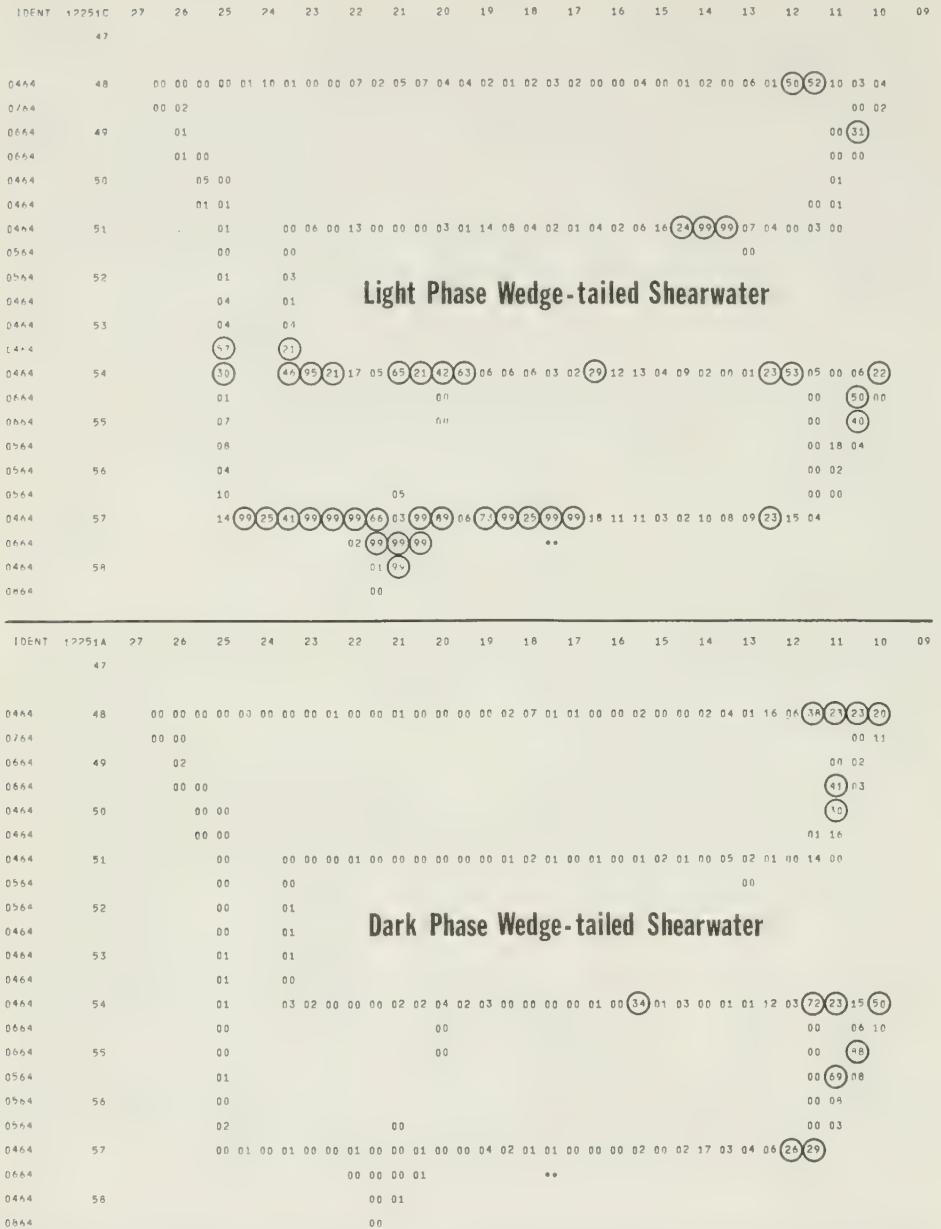


FIGURE 9.—Computer printed distribution maps of two color phases of wedge-tailed shearwaters May–July. Four-digit numbers in extreme left margin refer to *Cromwell* cruises by month and year on which first observation in that line was made. Note that, on April and July cruises, observations were made in May and August. North is to the left, latitude is read from right to left, and longitude from top to bottom. The cruise track is outlined by the number print-out. Asterisks indicate no observations were made in that half-degree square, 00 indicates observations but no birds. Abundance may be read directly from the printed numbers. Circles indicate 20 birds or more per half-degree square.

day cards. Only those sightings that were made within the time interval on the fractional day card are flagged for special parametric analysis. Because the data are flagged on the basis of times of observation, the computer does not require geographic information to define the area; thus, bird densities may be computed for areas of any size or shape. These areas may be mutually exclusive or may overlap wholly or in part (fig. 10). The computer also will provide density figures based on total observations made within a given area during all fractional days within a requested time span. Areas may

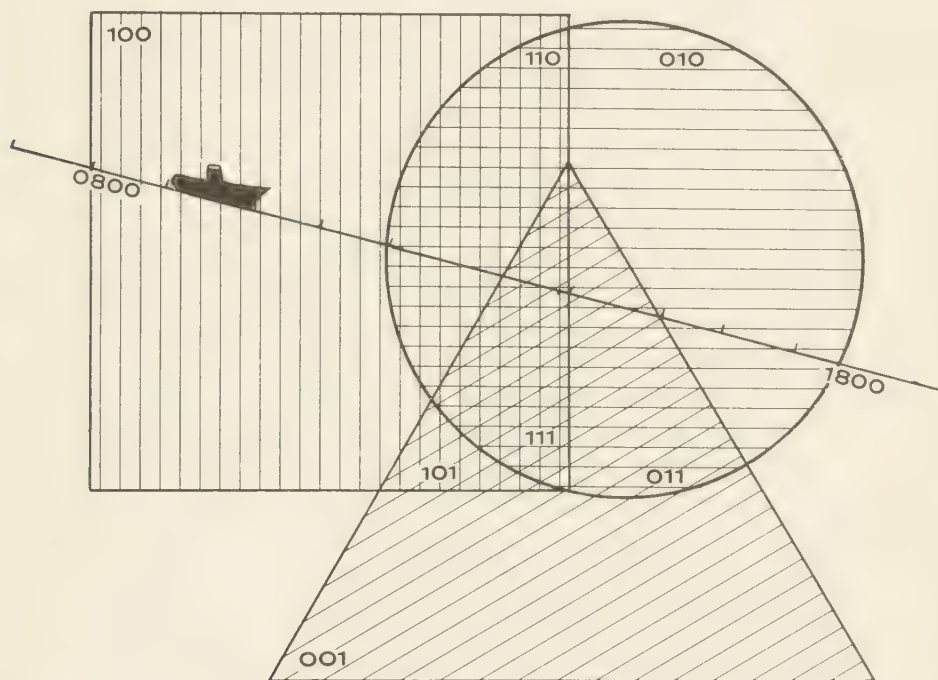


FIGURE 10.—Three overlapping areas along a day's cruise path with the coded representations for various subareas. All sightings made within the time the ship was in the square are flagged with a 1 in first column of the SPA field; those in the circle and the triangle, with 1's in the second and third columns respectively.

be selected for special parametric analysis either before the data have been entered on punch cards or at any future time by fractionizing the appropriate day cards.

The revised intermediate coded sheet for the day card is shown in figure 3.

Plankton measurements were made only once daily on the *Cromwell* cruises, but in other programs plankton abundance may be sampled more frequently. The plankton field (62–64), therefore, should be moved to the environment card where it would occupy columns 69–71.

Primary productivity, a measurement of the richness of environment and potential food supply, eventually may prove useful for comparison with bird distribution. At present, however, because there is no universally agreed-upon measure of productivity, we have used surface phosphate and plankton abundance as measures of the marine environment.

The data stored on tape reels in the computer may be altered through a revised program if these or any later modifications become necessary.

With some modifications, the coding used in this pilot seabird ADP system is suitable for storage of seabird records voluntarily sent in from all over the world to a central office or offices such as World Data Centers A and B for Oceanography in Washington and Moscow. Information submitted on standardized forms would be available for use by marine ornithologists and ecologists. The establishment of a world center for the storage of seabird distribution data and international agreement on uniform methods of observation, recording, and coding of data were two basic recommendations of a seabird committee authorized by the 14th International Ornithological Congress, Oxford, July 1966.

Varying reliability of observations and different techniques for gathering data, however, probably will necessitate uniform editing before the data are fed into the system. This suggests the need for a central editor for all the data and a staff to prepare them for entry. As an indication of the extent of the work that may be needed to prepare data for computer storage, two persons worked full time eight hours a day for 50 days transferring the raw at-sea data from the *Cromwell* cruises onto intermediate coded sheets before they could be punched into the system. Because of the far larger volume of data that may be collected by many more observers from all over the world in an international program, it might be necessary for them to submit data to the proposed editor or central files already translated onto intermediate coded sheets.

The worldwide scope of such a seabird data storage project and the fact that many species of seabirds associate with commercially valuable schooling fish make this an attractive candidate for support under the International Biological Program, the major theme of which is productivity and man.

TABLE 1.--Codes for sighting deck

Species Identification for Central Pacific Ocean: 29-34

100000 Aves

120000 Procellariiformes

121000 Diomedidae

121100 *Diomedea*121110 *D. nigripes*121111 *D. immutabilis*121112 *D. melanophris*

122000 Procellariidae

122100 *Fulmarus*122101 *F. glacialis*122500 *Puffinus*122501 *P. carneipes*122504 *P. creatopus*122506 *P. pacificus*122518 *P. bulleri*122519 *P. griseus*122520 *P. tenuirostris*122521 *P. nativitatus*122524 *P. puffinus newelli*122534 *P. lherminieri*122600 *Pterodroma*122601 *P. hasitata*122607 *P. h. phaeopygia*122608 *P. h. externa*122609 *P. h. cervicalis*122615 *P. solandri*122620 *P. rostrata*122624 *P. inexpectata*122629 *P. hypoleuca*122630 *P. h. hypoleuca*122631 *P. h. nigripennis*122633 *P. neglecta*122636 *P. alba*122642 *P. arminjoniana heraldica*122645 *P. cooki*122646 *P. cooki cooki*122649 *P. leucoptera*122653 *P. l. masafuerae*

- 122700 *Bulweria*
 - 122701 *B. bulwerii*
- 123000 Hydrobatidae
 - 123100 *Oceanites*
 - 123101 *O. oceanicus*
 - 123400 *Oceanodroma*
 - 123404 *O. castro*
 - 123409 *O. leucorhoa*
 - 123420 *O. tristrami*
 - 123423 *O. furcata*
 - 123500 Miscellaneous genera
 - 123502 *Nesofregetta albigularis*
- 130000 Pelecaniformes
 - 131000 Phaethontidae
 - 131100 *Phaethon*
 - 131106 *P. rubricauda*
 - 131112 *P. lepturus*
 - 133000 Sulidae
 - 133200 *Sula*
 - 133206 *S. dactylatra*
 - 133213 *S. sula*
 - 133217 *S. leucogaster*
- 136000 Fregatidae
 - 136100 *Fregata*
 - 136107 *F. minor*
 - 136114 *F. ariel*
- 140000 Charadriiformes
 - 141000 Charadriidae
 - 141200 *Pluvialis*
 - 141209 *P. dominica*
 - 141400 *Arenaria*
 - 141401 *A. interpres*
 - 142000 Scolopacidae
 - 142100 *Numenius*
 - 142101 *N. tahitiensis*
 - 142200 *Heteroscelus*
 - 142201 *H. incanum*
 - 142700 *Crocethia*
 - 143000 Phalaropodidae
 - 143100 *Phalaropus*
 - 143101 *P. fulicarius*

- 144000 Stercorariidae
 - 144100 *Stercorarius*
 - 144101 *S. pomarinus*
 - 144103 *S. longicaudus*
 - 144200 *Catharacta*
 - 144201 *C. skua*
- 145000 Larinae
 - 145100 *Larus*
 - 145101 *L. arcticilla*
 - 145145 *L. delawarensis*
 - 145184 *L. glaucescens*
 - 145185 *L. hyperboreus*
- 146000 Sterninae
 - 146100 *Anous*
 - 146101 *A. stolidus*
 - 146110 *A. tenuirostris*
 - 146200 *Procelsterna*
 - 146201 *P. cerulea*
 - 146300 *Gygis*
 - 146301 *G. alba*
 - 146800 *Sterna*
 - 146801 *S. bergi*
 - 146829 *S. hirundo*
 - 146835 *S. paradisaea*
 - 146857 *S. sumatrana*
 - 146866 *S. lunata*
 - 146867 *S. fuscata*

TABLE 2.--Codes for sighting deck

Species identification reliability: 36	Number reliability: 42
0 Sighting as a whole reliable	0 Actual count
1 Sighting as a whole questionable	1 $\pm$ 5 per cent
2 Either this or next most similar	2 $\pm$ 10 per cent
form	3 $\pm$ 15 per cent
3 This or any similar form	4 $\pm$ 20 percent
4 Genus reliable, species	5 $\pm$ 25 percent
unreliable	6 $\pm$ 30 or 33 per cent
5 Genus unreliable, species	7 $\pm$ 40 per cent
unreliable	8 $\pm$ 50 per cent
6 Sighting as whole unreliable	9 Present, but no count possible

Direction of bird movement: 43

- 0 No data
- 1 No apparent direction
- 2 North
- 3 Northeast
- 4 East
- 5 Southeast
- 6 South
- 7 Southwest
- 8 West
- 9 Northwest

Behavior: 44

- 0 No information
- 1 Traveling
- 2 Sitting
- 3 Feeding
- 4 Searching
- 5 Following ship
- 6 Breeding (display)
- 7 Parasitism
- 8 Dispersing
- 9 Other

Color marking: 45

- 0 No data
- 1 Orange
- 2 Blue
- 3 Red
- 4 Green
- 5 Black
- 6 White
- 7 Yellow
- 8 Brown
- 9 Other

Method of marking: 46

- 0 No data
- 1 Painted
- 2 Band
- 3 Colored band
- 4 Streamer
- 5 Other

Age: 47

- 0 Not determined
- 1 Adult
- 2 Sub-adult
- 3 Immature
- 4 1st year
- 5 2nd year
- 6 3rd year

Sex: 48

- 0 Not determined
- 1 Male
- 2 Female

Color-plumage phase: 49

- 0 Not determined
- 1 Light phase
- 2 Intermediate phase
- 3 Dark phase
- 4 Pink
- 5 Other

Molt: 50

- 0 Not determined
- 1 Molt not present
- 2 Molt present
- 3 New plumage
- 4 Worn plumage
- 5 Other

Specimen: 51

0 Not collected

1 Collected

Special weather conditions: 53

0 No data

1 Birds in rain

2 Bird at edge of rain

3 Very high winds

4 Calm

5 Other

Food association: 52

0 Not determined

1 Flying fish

2 Predatory fish

3 Squid

4 Plankton

5 Food fish

6 Scavenging

7 Other

Special information: 54

0 No data

1 Identification

2 Species association

3 Behavior

4 Abundance

5 Location

6 Direction of movement

7 Food association

8 Other

9 Parasitism

TABLE 3.--Codes for environmental deck

Weather conditions: 50-51

00-49 No precipitation at the ship at the time of observation.

00-19 No precipitation, fog, duststorm, sandstorm, or drifting snow at the ship at the time of observation or during the preceeding hour, except for 09.

00 Cloud development not observed or not observable.

01 Clouds generally dissolving or becoming less developed.

02 State of sky on the whole unchanged.

03 Clouds generally forming or developing.

} No hydrometers except clouds.

} Characteristic change of the state of sky during past hour.

- | | | | |
|----|--|---|--|
| 04 | Visibility reduced by smoke, e.g., veldt or forest fires, industrial smoke, or volcanic ashes. | } | Haze, dust, sand, or smoke. |
| 05 | Dry haze. | | |
| 06 | Widespread dust in suspension in the air, not raised by wind at or near the ship at the time of observation. | | |
| 07 | Dust or sand raised by wind at or near the ship at the time of observation, but no well-developed dust devil(s), and no duststorm or sandstorm seen. | | |
| 08 | Well-developed dust devil(s) seen at or near the ship within last hour, but no duststorm or sandstorm. | | |
| 09 | Duststorm or sandstorm within sight of the ship or at the ship during the last hour. | } | Shallow fog at the ship not deeper than about 33 feet. |
| 10 | Light fog (visibility 1,100 yards or more). | | |
| 11 | Patches of. | } | |
| 12 | More or less continuous. | | |
| 13 | Lightning visible, no thunder heard. | | |
| 14 | Precipitation within sight but not reaching surface at the ship. | | |
| 15 | Precipitation within sight, reaching surface, but distant (i.e., estimated to be more than 3 miles from the ship). | | |
| 16 | Precipitation within sight, reaching surface, near to but not at the ship. | | |

- | | | |
|-------|--|--|
| 17 | Thunder heard, but no precipitation at the ship. | |
| 18 | Squall(s) | } Within sight during the last hour. |
| 19 | Funnel cloud(s) (tornado or waterspout). | |
| 20-29 | Precipitation, fog or thunderstorm at the ship during the preceding hour but NOT at the time of observation. | |
| 20 | Drizzle (not freezing). | } Not falling as showers. |
| 21 | Rain (not freezing). | |
| 22 | Snow. | |
| 23 | Rain and Snow. | |
| 24 | Freezing drizzle or freezing rain. | |
| 25 | Shower(s) of rain. | |
| 26 | Shower(s) of snow, or of rain and snow. | |
| 27 | Shower(s) of hail or of hail and rain. | |
| 28 | Fog. | |
| 29 | Thunderstorm (with or without precipitation). | |
| 30-39 | Duststorm, sandstorm or drifting snow. | |
| 30 | Slight or moderate duststorm or sandstorm. | Has decreased during preceding hour. |
| 31 | Slight or moderate duststorm or sandstorm. | No appreciable change during preceding hour. |
| 32 | Slight or moderate duststorm or sandstorm. | Has increased during preceding hour. |
| 33 | Severe duststorm or sandstorm. | Has decreased during preceding hour. |
| 34 | Severe duststorm or sandstorm. | No appreciable change during preceding hour. |
| 35 | Severe duststorm or sandstorm. | Has increased during preceding hour. |
| 36 | Slight or moderate drifting snow. | } Generally low. |
| 37 | Heavy drifting snow. | |
| 38 | Slight or moderate drifting snow. | } Generally high. |
| 39 | Heavy drifting snow. | |

40-49 Fog at the time of observation.

40 Fog at a distance at the time of observation, but not at the ship during the last hour, the fog extending to a level above that of the observer.

41 Fog in patches.

42 Fog, sky discernible.

43 Fog, sky not discernible.

44 Fog, sky discernible.

45 Fog, sky not discernible.

46 Fog, sky discernible.

47 Fog, sky not discernible.

48 Fog, depositing rime, sky discernible.

49 Fog, depositing rime, sky not discernible.

} Has become thinner during preceding hour.
} No appreciable change during preceding hour.
} Has begun or has become thicker during preceding hour.

50-99 Precipitation at the ship at the time of observation.

50-59 Drizzle at time of observation.

50 Drizzle, not freezing, intermittent.

51 Drizzle, not freezing, continuous.

52 Drizzle, not freezing, intermittent.

53 Drizzle, not freezing, continuous.

54 Drizzle, not freezing, intermittent.

55 Drizzle, not freezing, continuous.

56 Drizzle, freezing, slight.

57 Drizzle, freezing, moderate or thick.

58 Drizzle and rain, slight.

59 Drizzle and rain, moderate or heavy.

} Slight at time of observation.
} Moderate at time of observation.
} Thick at time of observation.

60-69 Rain at time of observation.

60 Rain, not freezing,
intermittent.61 Rain, not freezing,
continuous.62 Rain, not freezing,
intermittent.63 Rain, not freezing,
continuous.64 Rain, not freezing,
intermittent.65 Rain, not freezing,
continuous.

66 Rain, freezing, slight.

67 Rain, freezing, moderate or
heavy.68 Rain or drizzle and snow,
slight.69 Rain or drizzle and snow,
moderate or heavy.Slight at time of
observation.Moderate at time of
observation.Heavy at time of
observation.

70-79 Solid precipitation not in showers at time of observation.

70 Intermittent fall of snow
flakes.71 Continuous fall of snow
flakes.72 Intermittent fall of snow
flakes.73 Continuous fall of snow
flakes.74 Intermittent fall of snow
flakes.75 Continuous fall of snow
flakes.76 Ice needles (with or without
fog).77 Granular snow (with or
without fog).78 Isolated starlike snow
crystals (with or without
fog).

79 Ice pellets.

Slight at time of
observation.Moderate at time of
observation.Heavy at time of
observation.

80-99 Showery precipitation, or precipitation with current or recent thunderstorm.

- 80 Rain shower(s), slight.
- 81 Rain shower(s), moderate or heavy.
- 82 Rain shower(s), violent.
- 83 Shower(s) of rain and snow mixed, slight.
- 84 Shower(s) of rain and snow mixed, moderate or heavy.
- 85 Snow shower(s), slight.
- 86 Snow shower(s), moderate or heavy.
- 87 Shower(s) of soft or small hail with or without rain, or rain and snow, slight.
- 88 Shower(s) of soft or small hail with or without rain, or rain and snow mixed, moderate or heavy.
- 89 Shower(s) of hail with or without rain, or rain and snow mixed, not associated with thunder, slight.
- 90 Shower(s) of hail, with or without rain, or rain and snow mixed, not associated with thunder, moderate or heavy.
- 91 Slight rain at time of observation.
- 92 Moderate or heavy rain at time of observation.
- 93 Slight snow, or rain and snow mixed, or hail* at time of observation.
- 94 Moderate or heavy snow, or rain and snow mixed, or hail* at time of observation.

Thunderstorm during preceding hour but not at time of observation.

*Hail, small hail, soft hail.

- | | |
|--|--|
| 95 Thunderstorm, slight or moderate, without hail* but with rain and/or snow at time of observation. | } Thunderstorm at time of observation. |
| 96 Thunderstorm, slight or moderate, with hail* at time of observation. | |
| 97 Thunderstorm, heavy, without hail* but with rain and/or snow at time of observation. | |
| 98 Thunderstorm combined with duststorm or sandstorm at time of observation. | |
| 99 Thunderstorm, heavy, with hail* at time of observation. | |

*Hail, small hail, soft hail.

TABLE 4.--Codes for environmental deck

State of sea: 52	Moon age: 60
0 Flat calm	0 No data
1 Less than 1 foot	1 New
2 1 to 3 feet	2 1/4
3 3 to 5 feet	3 1/2
4 5 to 8 feet	4 3/4
5 8 to 12 feet	5 Full
6 12 to 20 feet	6 Not up
7 20 to 40 feet	
8 40 feet and over	
9 Very rough, confused sea	
Visibility: 53	Cloud cover: 61
0 Dense fog.....50 yards	0 No clouds
1 Thick fog 200 yards	1 Less than 1/10, or 1/10
2 Fog.....400 yards	2 2/10 and 3/10
3 Moderate fog 1000 yards	3 4/10
4 Thin fog or mist 1 mile	4 5/10
5 Visibility poor.....2 miles	5 6/10
6 Visibility moderate 5 miles	6 7/10 and 8/10
7 Visibility good 10 miles	7 9/10 and 9/10 plus
8 Visibility very good.....30 miles	8 10/10
9 Visibility excellent over 30 miles	9 Sky obscured
(Use range-finder readings of known land)	

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3610

BREDIN-ARCHBOLD-SMITHSONIAN BIOLOGICAL SURVEY OF DOMINICA

3. Marine Archiannelids from Dominica ¹

By ERNST KIRSTEUEER ²

This paper is based on collections made by the author on Dominica, B.W.I., during April 1966 from Middle Bay below the village of Marigot on the northeast coast of the island. Two species of archiannelids, *Saccocirrus archboldi*, new species, and *Protodrilus corderoi* Marcus, were found when sand samples were examined for psammobiontic nemerteans. Substrate samples were taken to a depth of 100 mm in the middle of the intertidal region and also from near low water line of the sandy beach. The substrate samples were placed together with sea water in pails, and after two to three days the surface layer of sand was examined for specimens with a dissecting microscope. In the samples from the midintertidal zone, both

¹ Other faunal studies in this series are: 1, Kier, Proc. U.S. Nat. Mus., 1966, vol. 121, no. 3577, pp. 1-9; 2, Stone, *ibid.*, 1966, vol. 121, no. 3578, pp. 1-6. A companion series on the flora appears in the "Contributions of the United States National Herbarium."

² Department of Living Invertebrates, American Museum of Natural History, New York, N.Y.

species of archiannelids were represented while in those samples from near the low water line only *Protodrilus corderoi* was found.

This investigation is a contribution of the "Bredin-Archbold-Smithsonian Biological Survey of Dominica" and I wish to express my thanks to Dr. Horton H. Hobbs, Jr., United States National Museum, for making my participation in the program possible. I am also indebted to Dr. Marian H. Pettibone and Dr. W. Duane Hope, USNM, for their comments and suggestive criticisms of the manuscript.

Genus *Saccocirrus* Bobretzky

Saccocirrus archboldi, new species

FIGURE 1

The new species is based on 11 specimens, five mature females and six immature specimens. The animals were studied alive but six worms (two females and four immature specimens) were fixed and later examined for further details.

TYPES.—One whole mount with three specimens is deposited in the United States National Museum. Female holotype, and two immature paratypes, USNM 34709. One whole mount with three specimens is deposited in the American Museum of Natural History, New York. Paratypes, one female and two immature specimens, AMNH 3876.

TYPE-LOCALITY.—Middle Bay, Dominica, British West Indies.

The new species is dedicated to Mr. John D. Archbold, who has helped support the present survey on Dominica.

DESCRIPTION.—The living animals measure 4 to 6 mm in length (the tentacles not included) and approximately 0.2 mm in width. The animals have 60 to 84 segments. The color of the worms is a light yellowish white and the greenish intestine can be seen through the body surface. The two black eyes are comparatively large and easily discernible in life. They are situated near the base of the prostomial tentacles, the latter attaining a length of about 600μ in the longest of the specimens. The tentacles taper gradually toward their distal ends and are beset with sparsely scattered, rather stiff sensory cilia, which are more numerous on the anterior side. The posterior surface of the tentacles is corrugated even when held straight. Stiff sensory cilia also occur on the anterior margin of the prostomium, on the lateral sides of the body, and on the dorsal side of the anal lobes. The nuchal organs are small, elliptic, ciliated pits and are found immediately behind the tentacles (fig. 1a).

The achaetous peristomial segment is twice as long as the following setigerous segments. The mouth slit extends over the whole length of the peristomial region and is lined by lips having a very active

ciliation. Parallel with the mouth, the two elongated tentacle ampullae reach caudad to the middle of the peristomium (fig. 1a). The pharynx occupies the second and third segments and the esophagus

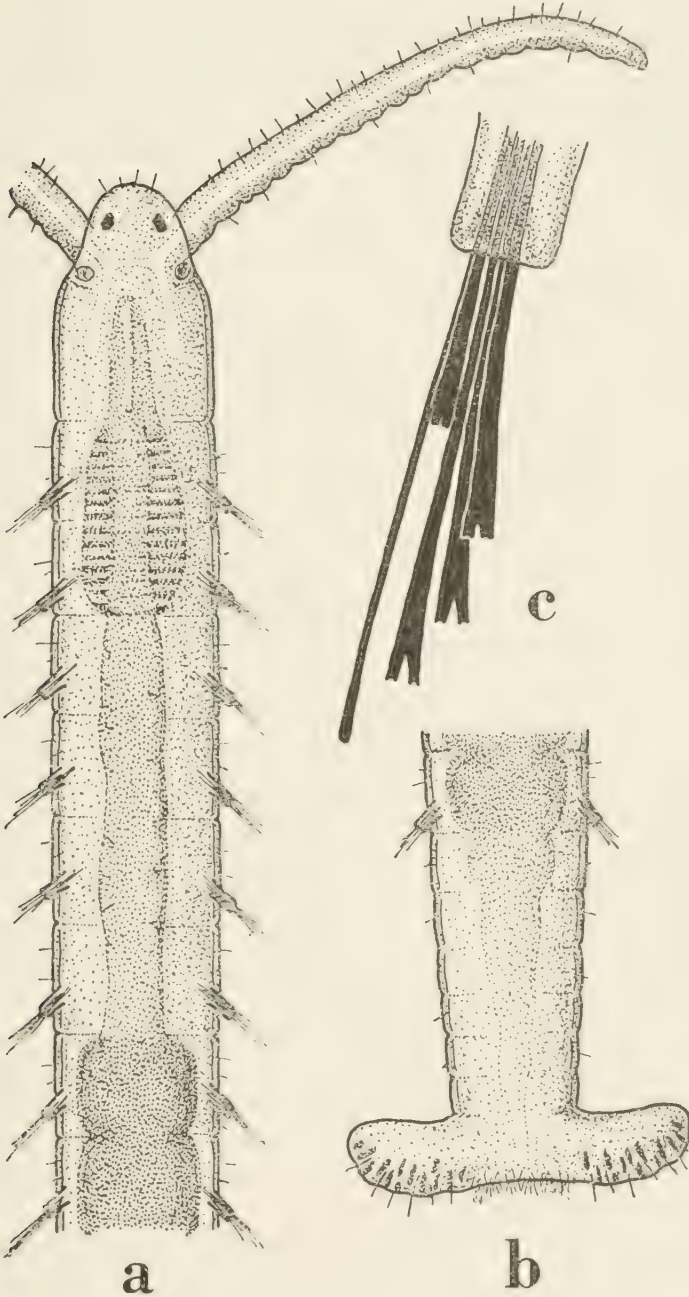


FIGURE 1.—*Saccocirrus archboldi*, new species: *a*, anterior region of a living animal in dorsal view; *b*, posterior portion of a living animal in dorsal view; *c*, parapodium with setae.

ends with the seventh segment. The following part of the alimentary tract shows (in living as well as in fixed specimens) intersegmental constrictions. It continues to the beginning of the achaetous and apodous posterior portion of the body, which comprises five to six segments and the pygidium. In this body region the intestine is a comparatively narrow and smooth tube that opens posteromedially on the pygidium in a ciliated area (fig. 1b).

Each setigerous segment is provided with a pair of dorsolateral parapodia that have a cylindrical shape and are about 80μ long. Each parapodium is furnished with five setae of different lengths. The longest seta (176μ) is flexible and hairlike and thickens slightly toward its rounded distal end. The other four bristles (152μ , 123μ , 98μ , and 74μ long) are broadened distally and bifurcated. The symmetrical prongs have a blunt end with a shallow depression (fig. 1c). The pygidium shows two rounded lobes that are moderately dorsoventrally flattened (fig. 1b). Though the margins of the lobes are somewhat wavy, there are no structures comparable with the adhesive papillae in some other species of this genus. Over the entire posterior aspect of the lobes, conspicuous gland cells are scattered that, with their secretion, obviously function as an adhesive device.

By examining the living mature worms, one finds the gonads in the segments posterior from the twenty-fifth or twenty-sixth to the beginning of the nonsetigerous body region.

DIAGNOSTIC FEATURES.—Yellowish-white worms, 4 to 6 mm long, with 60 to 84 segments; pygidium with two rounded anal lobes that have no cirri or demarcated adhesive papillae; cylindrical parapodia with five setae of which the longest one has a rounded tip and the other four are bifurcated at their distal ends.

REMARKS.—To the genus *Saccocirrus* Bobretzky the following species so far have been ascribed: *S. papillocercus* Bobretzky (1871), *S. major* Pierantoni (1907), *S. krusadensis* Alikunhi (1943, 1948), *S. minor* Aiyar and Alikunhi (1944), *S. cirratus* Aiyar and Alikunhi (1944), *S. gabriellae* Marcus (1946), *S. orientalis* Alikunhi (1946), *S. pussicus* Marcus (1948), *S. parvus* Gerlach (1953), and *S. maculatus* Tenerelli (1964). One unidentified species of *Saccocirrus* was mentioned by Berkeley (1936). It corresponds in the character of the setae to *S. papillocercus*, but the anal lobes are similar to those of *S. major*. Marcus (1946), however, considered Berkeley's specimens to be identical with *S. gabriellae*.

According to body length and configuration of the pygidium, the closest relatives of the new species are *S. parvus* Gerlach and *S. maculatus* Tenerelli. *Saccocirrus archboldi*, however, is distinguished from *S. parvus* by having longer and cylindrical parapodia with five setae, while in *S. parvus* the parapodia are short, conical protuberances

furnished with six setae. The type of setae is also different in these two species. In *S. parvus* the longest bristle is bifurcated and the other five bristles on each parapodium have broad and blunt tips; in *S. archboldi* the longest and hairlike seta has a round tip and the rest of the setae are distally bifurcated. *Saccocirrus maculatus* is clearly distinguished from *S. archboldi* by having only 26 segments and, further, by being marked with black dots, which are irregularly scattered over the greater part of the body surface but are so densely arranged on the pygidium that it looks black.

Genus *Protodrilus* Hatschek

Protodrilus corderoi Marcus

Protodrilus corderoi Marcus, 1948, pp. 5-7, figs. 11-16.

The nine specimens that were collected on Dominica agree in most details with the description given by Marcus (1948) for specimens from Brazil. The living worms are greyish in color, semitransparent, and attain a length up to 4 mm (in the Brazilian specimen, 6 mm) and a maximum width of 0.1 mm. Up to 37 segments are found in the present specimens. The head region is, under normal circumstances, only slightly wider than the rest of the body. In a squeezing preparation, however, the cephalic area becomes broadened and rounded in shape as was illustrated by Marcus (1948, pl. 3: fig. 11). The tentacles extend over 280μ and are irregularly beset with cilia. Cilia are found also on the tip of the prostomium, on the lateral and dorsal aspects of the body segments, and along the posterior border of the anal lobes. The nuchal organs are small ciliated pits situated posterior from the tentacles on the lateral sides of the head. There are no eyes, statocysts, or transverse bands of cilia.

The salivary glands extend posterior into the third segment in the smallest animal and into the seventh segment in the longest one. The two anal lobes have the same shape as was figured by Marcus (1948, pl. 3: fig. 12). In only two animals small ovocytes were found when studied alive. The other specimens were sexually immature.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3611

Butterflies of the New Genus *Calystryma* (Lycaenidae: Theclinae, Strymonini)

By William D. Field
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Calystryma, new genus, contains 13 species, all of which are neotropical in distribution. Six of the included species are herein described as new and the rest are transferred to *Calystryma* from *Thecla* Fabricius, where they have resided ever since they were first described in spite of the fact that they belong to the Strymonini (forewing having 3 radial veins) not to the Theclini (forewing having 2 radial veins). I designate as type of the genus: *Calystryma blora*, new species. The name *Calystryma* is an arbitrary, euphonous combination of letters and I consider it to be of the feminine gender.

Calystryma is closely related to *Calycopis* Scudder, differing chiefly in the form of the male and female genitalia.

In the male genitalia the uncus is divided dorsally into two lateral elements that in lateral view are produced greatly near the middle, thus differing from *Calycopis*. Vesica of aedeagus with a single spine-like cornutus located at or near distal end of aedeagal shaft. Aedeagus lacking the ventral keel found in some Strymonini and nearly straight or sometimes upturned distally, with this end usually blunt, not sharply pointed as in *Calycopis*. Harpes differing from those of *Calycopis* in being separate along ventral margin, fused only at base or in one case (*C. keta*) fused for nearly one-half their lengths from base. This last species, however, has the *Calystryma* type of uncus

and eighth tergite. Gnathos divided into two separate armlike parts, each with an elbow bend near or before middle and with apical part (forearm) often with carina along inner surface; carina either laminate or dentate.

Eighth tergite of male abdomen subcordate in shape with a broad and deeply incised posterior concavity, usually much more deeply incised than in *Calycopsis*.

Female genitalia with ductus bursae a simple sclerotized tube, envelope shaped at ostium bursae with a superior genital plate above and a ventral genital plate below the ostium and usually with the free edge of the superior genital plate divided into two lateral elements bearing teeth or spurlike processes. In one species (*C. atrox*) this free edge is a long continuous ridge. Bursa copulatrix with two large platelike signa, each ornamented with a centrally placed spine that is rose-thorn in shape and with anterior margin deeply dentate. Signa thus similar to those of *Calycopsis*.

In habitus *Calystryma* is similar to *Calycopsis*, especially in that the forewings of the males lack the scent pads frequently found in the Theclinae and in having some shade of red in the area between the large blue lunule in interspace Cu_2 and the postmedian tripartite line on the undersurface of the hindwing. In *Calystryma* the red inner lining along the postmedian tripartite line on undersurface of the hindwing is reduced greatly or lacking with the $Sc+R_1$ element of this line very distinctly outlined with black, forming a black and white bar that stands out sharply from the rest of this line. Except in four species (*C. atrox*, *C. malta*, *C. anapa*, and *C. gentilla*) there are two submarginal ecellate spots below vein M_3 on this same surface. The uppersurfaces of all but one species (*C. trebula*) are either entirely dark brown or very dark brown covered with dull metallic purple. The males of *C. trebula* have the hindwing dark iridescent or shining blue and thus resemble most of the species of *Calycopsis* in this respect.

The author wishes to acknowledge with thanks the cooperation and aid of A. G. Gabriel, T. G. Howarth, N. H. Bennett, and D. S. Fletcher, all of the Department of Entomology, British Museum (Natural History), London, and Frederick H. Rindge, Department of Entomology, American Museum of Natural History, New York. The late William P. Comstock of the last named museum also greatly helped the author.

The figures of the male and female genitalia and of the eighth tergites of the males were drawn under the author's supervision by Andre D. Pizzini, staff artist. All photographs were made by Jack Scott, staff photographer, except figures 1 through 4 on plate 3, which were furnished by the courtesy of D. S. Fletcher on the staff of the British Museum (Natural History).

Key to the Species of *Calystryma*

MALES (except *C. cinniana*)

- 1. Uppersurfaces of hindwings bright blue 11. **C. trebula**
Uppersurfaces of hindwings not as above 2
- 2. (1) Harpes separate along ventral margin, fused only at base; posterior lobes
of 8th tergite blunt or rounded (figs. 2-12) 3
Harpes fused along ventral margin for nearly one-half their length from
base; posterior lobes of 8th tergite acute (fig. 1) 1. **C. keta**
- 3. (2) Harpe with apex bifurcate; uncus deeply bilobed dorsally (fig. 12). . .
. 12. **C. tifla**
Harpe with apex blunt or gradually acuminate, not bifurcate; uncus
only shallowly bilobed dorsally (figs. 2-11) 4
- 4. (3) Harpe short and blunt and in lateral view slightly concave distally
(figs. 6, 7) 5
Harpe longer and gradually more narrow toward distal end (figs. 2-5,
8-10) 6
- 5. (4) Ground color of wings above brown 6. **C. malta**
Ground color of wings above dull metallic purple, slightly dull green
at base 7. **C. anapa**
- 6. (4) 8th tergite deeply incised in middle of posterior margin and greatly
elongated anteriorly (figs. 8-10) 7
8th tergite more shallowly incised in middle of posterior margin and
not distinctly elongated anteriorly (figs. 2-5) 9
- 7. (6) Ground color of uppersurfaces of wings brown 10. **C. barza**
Ground color of uppersurfaces of wings dull metallic purple 8
- 8. (7) Hindwing underneath with a single submarginal pupillated red lunule,
this in interspace Cu₁ and small with a large pupil (nearly ½ the size
of entire lunule) 8. **C. gentilla**
Hindwing underneath with two submarginal pupillated red lunules,
one in interspace Cu₁ and the second in interspace M₃, both lunules
with small pupils (not nearly ½ size of lunules) 9. **C. pisis**
- 9. (6) Posterior projection of uncus broadly rounded (fig. 5); ground color of
wings above dull metallic purple with greenish reflections in base.
. 5. **C. meleager**
Posterior projection of uncus narrow and toothlike or beaklike (figs.
2-4); ground color of wings above brown 10
- 10. (9) Ground color of wings underneath distinctly brown; with a single sub-
marginal pupillated red lunule in interspace Cu₁ 2. **C. atrox**
Ground color of wings underneath light gray or pale brownish gray;
with two submarginal pupillated red lunules, one in interspace Cu₁
and one in interspace M₃ 11
- 11. (10) Ground color of wings underneath pale brownish gray with a large and
distinct red streak adjacent to inner side of postmedian line in inter-
space Cu₁ 4. **C. naka**
Ground color of wings underneath light gray without the triangular red
streak, at most with a small red lunule in this area 3. **C. blora**

FEMALES (except *C. blora* and *C. barza*)

- 1. Superior genital plate with free edge a long continuous ridge (fig. 13).
. 2. **C. atrox**
Superior genital plate with free edge divided into two lateral elements
(figs. 14-23) 2

2. (1) Superior genital plate with each element broadly rounded and bluntly toothed if toothed at all (figs. 20, 21, 23) 3
 Superior genital plate with each element having strong spurlike processes (figs. 14-19, 22) 5
3. (2) Superior genital plate with each element broadly rounded (fig. 23).
 9. **C. pisis**
 Superior genital plate with each element rounded and bluntly toothed anteriorly (figs. 20, 21) 4
4. (3) Superior genital plate greatly projected mesially on posterior edge (fig. 20) 12. **C. tiffa**
 Superior genital plate indented mesially on posterior edge (fig. 21).
 5. **C. meleager**
5. (2) Posterior spurlike processes on superior genital plate directed inward toward one another; anterior spurlike process greatly reduced and directed distad (fig. 22) 4. **C. naka**
 Posterior and interior spurlike processes on superior genital plate distally directed; anterior spurlike processes not as greatly reduced (figs. 14-19) 6
6. (5) Anterior spurlike processes on superior genital plate widely separated and much larger than posterior spurlike processes (fig. 14) . . . 1. **C. keta**
 Anterior and posterior spurlike processes on superior genital plate not widely separated; if so, then anterior spurlike processes not larger than posterior spurlike processes (figs. 15-19) 7
7. (6) Posterior spurlike processes greatly reduced or rounded and lobelike (figs. 16, 19) 10
 Posterior spurlike processes large, sharply pointed and extended (figs. 15, 17, 18) 8
8. (7) Anterior spurlike processes on superior genital plate sickle shaped and widely separated from posterior spurlike processes (fig. 17). 8. **C. gentilla**
 Anterior spurlike processes on superior genital plate nearly straight, not sickle shaped and not widely separated from posterior spurlike processes (figs. 15, 18) 9
9. (8) Posterior margin of superior genital plate between posterior spurlike processes nearly straight (fig. 18) 11. **C. trebula**
 Posterior margin of superior genital plate between posterior spurlike processes with broad shallow lobes and concave in middle (fig. 15).
 7. **C. anapa**
10. (7) Posterior spurlike processes on superior genital plate rounded and lobelike (fig. 16) 6. **C. malta**
 Posterior spurlike processes on superior genital plate reduced and bluntly acute, not lobelike (fig. 19) 13. **C. cinniana**

Check List of Species

- | | |
|--|---|
| 1. <i>Calystryma keta</i> , new species | 8. <i>C. gentilla</i> (Schaus), 1902, new combination |
| 2. <i>C. atrox</i> (Butler), 1877, new combination | 9. <i>C. pisis</i> (Godman and Salvin), 1887, new combination |
| 3. <i>C. blora</i> , new species | 10. <i>C. barza</i> , new species |
| 4. <i>C. naka</i> , new species | 11. <i>C. trebula</i> (Hewitson), 1868, new combination |
| 5. <i>C. meleager</i> (Druce), 1907, new combination | 12. <i>C. tifla</i> , new species |
| 6. <i>C. malta</i> (Schaus), 1902, new combination | 13. <i>C. cinniana</i> (Hewitson), 1877, new combination |
| 7. <i>C. anapa</i> , new species | |

1. *Calystryma keta*, new species

FIGURES 1, 14; PLATES 1 (FIGS. 1, 2), 2 (FIG. 1)

MALE (pl. 1: figs. 1, 2).—Wings above dark brown. Hindwing with a broken white submarginal line below vein M_3 continued to 2d A, with a small orange-red spot on anal lobe and with a tiny triangular white spot at indentation above this lobe. Middle scales of fringe below vein Cu_2 white; tails Cu_1 and Cu_2 tipped with white and with a few long white scales in fringe at end of vein 2d A. Wings underneath with ground color pale gray. Lines at end of cell on both forewing and hindwing indistinct. Postmedian line on forewing pale, the outer portion dirty white in color. This line on hindwing more distinct with the white particularly distinct in the W-mark, in the anal area, and near costa. This line tripartite on this wing with the addition of orange red along its inner surface below vein M_3 and especially in interspace Cu_1 . Above vein M_3 this color is very faint if present at all. Hindwing with an orange-red postmedian lunule in interspace Cu_2 , with an orange-red bar above the white arch outlining the black anal lobe and with two marginal ocular markings of this color in interspaces M_3 and Cu_1 . The ocular marking in interspace Cu_1 is much the larger of the two, extending to or almost to the postmedian tripartite line.

Length of forewing 11.5–12.5 mm.

Male genitalia as illustrated by figures 1B-E with harpes fused for nearly one-half their length from base; with aedeagus distally curved upward; with gnathal arm blunt and having a mesially placed carina; lateral lobe of uncus very uniquely shaped, having a strong acute projection from near lower angle and with a strong projection from lower margin. Eighth tergite (fig. 1A) deeply incised in middle of posterior margin, elongated anteriorly, and with posterior lobes acute and toothed along inner sides.

FEMALE (pl. 2: fig. 1).—Forewing above dark brown with streaks of shining blue in base of wing below and above vein 2d A. Hindwing mostly bright shining blue except for a dark brown border extending around outer margin from the anal angle to costa and except for a dark brown ray extending through bottom of cell to outer margin just above vein M_3 (in one specimen) and with more of this color below vein Cu_1 in anal area (in both specimens). With a white marginal line above 2d A continued to vein M_1 . Anal lobe with a small orange-red spot. Wings underneath like those of the male except the black centers of the marginal ocular markings in interspaces M_3 and Cu_1 are distinctly smaller.

Length of forewing 11 mm.

Female genitalia as illustrated by figure 14 with ductus bursae and bursa copulatrix relatively long, the longest of any species of *Calystryma*, their combined length being about four times the width of superior genital plate; the latter with free edge divided into two lateral elements, each with a single pair of spurlike processes, the anterior spurlike process being very large and sickle shaped, the posterior spurlike process reduced in size and distally directed.

TYPE-LOCALITY.—Limón, Province of Limón, Costa Rica.

ADDITIONAL TYPE DATA.—Described from the holotype, male and eight male paratypes with data as follows: holotype, locality as given above, USNM type no. 34904, May, Collection William Schaus, genitalia preparation WDF no. 3168; five paratypes, La Florida, Costa Rica, March 1907, 500 ft., Collection William Schaus, genitalia preparations WDF nos. 3171, 3172, 3980, 3981, 3982; two paratypes, Guapiles, Costa Rica, September and May 1907, 850 ft., Collection William Schaus, genitalia preparations WDF nos. 3173, 3979; one paratype, Carillo, Costa Rica, Collection William Schaus, genitalia preparation WDF no. 5012. [Note: Eleven additional males from non-Costa Rican localities (Upper Rio Marañon, Peru, Chapare, Bolivia) are identified as *C. keta* but are not labelled paratypes because of the remoteness of their localities. While the author is satisfied that the two known female specimens upon which the above description of that sex is based are associated correctly, they are excluded also from the type series for the same reason.]

LOCATION OF TYPES.—Holotype and six paratypes in the United States National Museum, one paratype each in the collections of the British Museum (Natural History) and the American Museum of Natural History (New York).

DISTRIBUTION.—In widely separated localities from Costa Rica south to Peru, Bolivia, and Brazil.

COSTA RICA: Province of Limón, Limón (May), La Florida (500 ft., March); Province of San Jose, Carillo (no date), Guapiles (850 ft., May, September). PANAMA: Province of Colón, Porto Bello (April); Rio Trinidad (March). BRITISH GUIANA: Bonaico (no date). FRENCH GUIANA: Colony of Guiana, St. Laurent (no date). ECUADOR: Department Amazonas, Upper Rio Marañon (October); Department of Loreto, Achinamiza (6001 ft., January). BRAZIL: State of Rio de Janeiro, Rio de Janeiro (no date). BOLIVIA: Department of El Beni, Chapare (no date).

MATERIAL STUDIED.—Twenty males and two females, including their genitalia.

2. *Calystryma atrox* (Butler), new combination

FIGURES 2, 13; PLATES 1 (FIGS. 3, 4), 2 (FIGS. 2, 3), 3 (FIGS. 1, 2)

Tmolus atrox Butler, 1877, Trans. Ent. Soc. London, 1877, p. 140.—Comstock and Huntington, 1959, Journ. New York Ent. Soc., vol. 67, p. 82.

Thecla atrox (Butler).—Druce, 1907, Proc. Zool. Soc. London, 1907, p. 609.—Draudt, in Seitz, 1920, Die Gross-Schmetterlinge der Erde, vol. 5, p. 795; 1921, *ibid.*, pp. 824, 826.—Schaus, 1920, Ent. News, vol. 31, p. 176.

Thecla gentilla Schaus.—Schaus [incorrect synonymy] 1920, Ent. News, vol. 31, p. 176.—Draudt [not Schaus] in Seitz, 1921, Die Gross-Schmetterlinge der Erde, vol. 5, p. 824.—Comstock and Huntington, [not Schaus] 1960, Journ. New York Ent. Soc., vol. 68, p. 117.

MALE (pl. 1: figs. 3, 4; pl. 3: figs. 1, 2).—Wings above dark brown, lacking white marginal line on hindwing, otherwise as in *C. keta*. Wings underneath with ground color light brown. Hindwing on this surface with red markings darker, with black pupil that centers marginal ocular marking in interspace M_3 in *C. keta*, absent in this species and with black pupil in ocular marking of interspace Cu_1 much larger than in *C. keta*, *C. blava*, or *C. naka*. The red marking inward from this pupil smaller, not extending to postmedian tripartite line. The latter is faintly outlined with red along its inner side only below vein Cu_1 , otherwise as in *C. keta*.

Length of forewing 12.5–14 mm.

Male genitalia as illustrated by figures 2B–E with harpes fused only at base; with aedeagus distally curved upward (much more than in *C. keta*) and curved also to the right; with gnathal arm acute and lacking a carina but in ventral view it is sometimes thickened just before distal end; as in the other species of *Calystryma* the shape of

the lateral lobe of the uncus is a most useful distinguishing character; in *C. atrox* the posterior projection is beaklike in shape and arises from near middle of distal margin. Eighth tergite (fig. 2A) incised more shallowly along posterior margin than in *C. keta*, not distinctly elongated anteriorly and with posterior lobes blunt.

FEMALE (pl. 2: figs. 2, 3).—Forewing above dark brown in the outer one-half of wing, dull metallic purple on the basal one-half. Hindwing entirely dull metallic purple except for indistinct dark brown marginal spots in anal area below vein Cu_1 and a white marginal line extending from anal angle to vein M_3 . Orange-red spot on anal lobe faintly indicated. Wings underneath entirely like the male except for a smaller black center in the marginal ocular marking on interspace Cu_1 .

Length of forewing 12 mm.

Female genitalia as illustrated by figure 13 with ductus bursae and bursa copulatrix relatively short, their combined lengths being about three and one-half times the width of the superior genital plate; the latter with free edge a long continuous ridge having lateroposterior angles that are projected slightly and bluntly.

TYPE-LOCALITY.—“Pedroso, Rio Purus, State of Amazonas, Brasil.”

ADDITIONAL TYPE DATA.—Described by Butler from a single specimen, the holotype, male (Sept. 25, 1876, James W. H. Trail), now in the collection of the British Museum (Natural History) and labeled with type number “Rh. 911” and with male genitalia preparation number “R. 1951 NHB 493.” This holotype is illustrated by figures 1 and 2 on plate 3.

LOCATION OF TYPE.—In the British Museum (Natural History).

METHOD OF IDENTIFICATION.—A topotype was not available for comparison with the holotype; however, a specimen from French Guiana was found by D. S. Fletcher that is identical in habitus and genitalia with the type. Through the courtesy of A. G. Gabriel the compared specimen was sent to me for study and, together with the photograph of the type (pl. 3: figs. 1, 2), is the basis for the present identification.

DISTRIBUTION.—In widely separated localities in British Guiana, French Guiana, Brazil, and Peru.

BRITISH GUIANA: Demerara County, Wismar (December). FRENCH GUIANA: Colony of Guiana, St. Laurent (no date). PERU: Department of Loreto, Rio Morona (6003 ft., January). BRAZIL: State of Amazonas, Pedroso, Rio Purus (September).

MATERIAL STUDIED.—Five males and one female, including their genitalia.

3. *Calystryma blora*, new species

FIGURE 3; PLATES 1 (FIGS. 5, 6), 2 (FIGS. 5, 6)

MALE (pl. 1: figs. 5, 6).—Very similar to *C. keta* in maculation, with ground color of wings above dark brown and with white marginal line on hindwing absent or greatly reduced (sometimes indicated by a few scattered white scales). Wings underneath as in *C. keta* with a pale gray ground color and with two marginal ocular markings, one each in interspaces M_3 and Cu_1 , the latter being distinctly larger. On the hindwing, on this surface, the orange red is more indistinct on the inner side of the postmedian tripartite line in interspace Cu_1 than in *C. keta*. Other markings quite like those of *C. keta*.

Length of forewing 11.5–12.5 mm.

Male genitalia as illustrated by figures 3B–E with harpes fused only at base; with aedeagus slightly curved upward at distal end about as in *C. keta*; with gnathal arm distally acute and having a carina past the middle near the distal end; with lateral lobe of uncus having a downward directed beaklike posterior projection and with a minimal projection on lower margin. Eighth tergite (fig. 3A) subcordate in shape, shallowly incised along posterior margin, distinctly elongated anteriorly and with posterior lobes blunt. Easily separated from *C. keta* by the shape of the gnathal arm, of the lateral lobe of uncus, and of the eighth tergite.

FEMALE (pl. 2: figs. 5, 6).—Forewing above quite like that of *C. keta*. Hindwing similar to that of *C. keta* with blue more extensive in anal area, the dark brown being restricted to the outer border and anal veins. Red spot on anal lobe present but very faint. Wings underneath very similar to those of the male, differing only in having smaller marginal ocular markings with correspondingly smaller black centers.

Length of forewing 12 mm.

Female genitalia unknown as the abdomen of the sole specimen is missing.

TYPE-LOCALITY.—St. Jean, Maroni River, Colony of Guiana, French Guiana.

ADDITIONAL TYPE DATA.—Described from the holotype male and five male paratypes with data as follows: holotype, locality as given above, USNM type no. 24905, Collection William Schaus, genitalia preparation WDF no. 3166; two paratypes, same locality and collection, genitalia preparations WDF nos. 3167, 3983; one paratype, St. Laurent, French Guiana, Collection E. I. Huntington, American Museum of Natural History; genitalia preparation WDF no. 5006;

two paratypes, Rockstone, Essequibo, British Guiana, genitalia preparations WDF nos. 3175, 3984. [Note: The single female specimen (from Shudihar River, British Guiana) that I associate with the males of this species and upon which the present habitus description was made was not designated the allotype because it lacks its abdomen.]

LOCATION OF TYPES.—Holotype and four paratypes in the United States National Museum. One paratype in the American Museum of Natural History (New York).

DISTRIBUTION.—Known only from French and British Guiana.

FRENCH GUIANA: Colony of Guiana, St. Jean (no date), St. Laurent (no date). BRITISH GUIANA: County?, Shudihar River (January); Essequibo County, Rockstone (no date).

MATERIAL STUDIED.—Six males, including their genitalia.

4. *Calystryma naka*, new species

FIGURES 4, 22; PLATES 1 (FIG. 7), 2 (FIG. 4)

MALE (pl. 1: fig. 7).—Wings above quite like those of *C. atrox* and *C. blora*, dark brown in color and without a white marginal line on hindwing. Wings underneath with ground color pale brown, much lighter in color than in *C. atrox* with markings quite like those of *C. blora* except that there is more orange red on inner side of tripartite postmedian line, especially in interspace Cu_1 , this color covering an even larger area on this interspace than it does in *C. keta*.

Length of forewing 12–13 mm.

Male genitalia as illustrated by figures 4B–E with harpes fused only at base; with distal one-half of aedeagus gradually curved upward and thus somewhat similar to that of *C. atrox* but not as in that species curved to the right; with gnathal arms distally acute and bearing a small carina near distal end; with lateral lobe of uncus having a downward directed beaklike posterior projection and with a minimal projection on lower margin and thus similar to *C. blora*, differing from the latter in having the upper angle of this lobe greatly projected. Eighth tergite (fig. 4A) similar to that of *C. keta*, with posterior margin deeply incised and distinctly elongated anteriorly. Differing greatly from that species in having the large posterior lobes evenly rounded.

FEMALE (pl. 2: fig. 4).—Forewing above dark brown except for a large shining blue area covering base of wing below cell to the inner margin. Hindwing covered by this same shining blue except the anal area, the veins on the outer half of wing, and the outer fringe, which are all dark brown. A single tiny brown marginal spot in interspace Cu_1 is all that is present to represent the dark brown border found

in *C. keta* and *C. blora*. Without a white line around outer margin and with anal lobe lacking red spot. Wings underneath like those of the male with smaller black centers to the marginal ocular markings.

Length of forewing 12.5 mm.

Female genitalia as illustrated by figure 22 with ductus bursae and bursa copulatrix relatively short, their combined lengths being just under three and one-half times the width of superior genital plate; the latter with its free edge divided into two lateral elements, each with a large posterior and mesially directed spurlike process and a small anterior and distally directed spurlike process, the latter greatly reduced and toothlike.

TYPE-LOCALITY.—“Upper” Rio Maranon, Department of Amazonas, Peru.

ADDITIONAL TYPE DATA.—Described from the holotype male and allotype female and three male paratypes with data as follows: holotype, locality as given above, 6101 ft., Dec. 30, 1924, H. Bassler Collection, genitalia preparation WDF no. 5003; allotype, same locality, elevation, and collection, Jan. 2, 1925, genitalia preparation WDF no. 5085; one paratype, same locality, elevation, and collection, Dec. 31, 1924, genitalia preparation WDF no. 3156; two paratypes, Rio Santiago, Department of Amazonas, Peru, 6140 ft., Oct. 6, 1924, and Nov. 20, 1924, H. Bassler Collection, genitalia preparations nos. 5001 and 5002.

LOCATION OF TYPES.—Holotypes, allotype, and two paratypes in the American Museum of Natural History (New York). One paratype in the United States National Museum.

DISTRIBUTION.—Known only from the Department of Amazonas in Peru.

MATERIAL STUDIED.—Four males and one female, including their genitalia.

5. *Calystryma meleager* (Druce), new combination

FIGURES 5, 21; PLATES 1 (FIG. 8), 2 (FIG. 7), 3 (FIGS. 3, 4).

Thecla meleager Druce, 1907, Proc. Zool. Soc. London, 1907, p. 618.—Draudt, *in* Seitz, 1920, Die Gross-Schmetterlinge der Erde, vol. 5, p. 800; 1921, *ibid.*, vol. 5, p. 829.—Comstock and Huntington, 1961, Journ. New York Ent. Soc., vol. 69, p. 165.

MALE (pl. 1: fig. 8; pl. 3: figs. 3, 4).—Wings above dark brown covered with dull metallic purple. Wings underneath with ground color gray, darker gray than in *C. keta* and *C. blora* and with similar markings. All red color darker and covering about same area as it does in *C. blora* and with the pupil centering the marginal ocular marking of interspace Cu_1 very large, even larger than it is in *C. atrox*.

Length of forewing 13–15 mm.

Male genitalia as illustrated by figures 5B-E with harpes fused only at base; with aedeagus fairly straight, not curved upward at distal end and thus differing from all the other species of *Calystryma* except *C. trebula* (from which it is easily separated by the shape of the harpes, gnathal arms, and saccus); with gnathal arm distally acute and having a large carina near middle; with lateral lobe of uncus broadly produced below middle and with a minimal projection on lower margin. Eighth tergite (fig. 5A) shallowly incised along posterior margin, subtriangular in shape and with blunt posterior lobes. This structure most similar to that of *C. blora* but more triangular in shape.

FEMALE (pl. 2: fig. 7).—Wings above brown, much lighter in shade than in the species heretofore described. Hindwing with a slightly darker brown marginal spot on interspace Cu_1 and with a thin white marginal line around outer margin from 2d A to vein R_s , this line very faint above vein M_2 . Anal lobe with a small pale orange-red spot. Wings underneath similar to those of male with marginal ocular marking of interspace M_3 very faint and with black center of marginal ocular marking of interspace Cu_1 triangular in shape.

Length of forewing 12.5 mm.

Female genitalia as illustrated by figure 21 with ductus bursae and bursa copulatrix relatively short, shorter than in any species of *Calystryma* except *C. tiffa* and shorter than in *C. malta* (even though the relative length compared to width of the superior genital plate in *C. malta* is less), their combined lengths being under three and one-half times the width of the superior genital plate; the latter with its free edge divided into two lateral elements, each with the posterior spurlike process found on related species replaced by a broad lobe and each with the anterior spurlike process reduced in size, indicated by short and broadly pointed lobes.

TYPE-LOCALITY.—Dutch Guiana ("Surinam").

ADDITIONAL TYPE DATA.—Originally described by Druce from seven specimens of both sexes. Since no single specimen was stated to be the type in the original description, all seven of these specimens are therefore syntypes (art. 73, pars. *b* and *c* of the "International Code of Zoological Nomenclature" adopted by the XV International Congress of Zoology and published in London in 1961). I hereby designate as the lectotype the one labeled type (with the type no. Rh. 962, genitalia preparation no. R. 1951 NHB 495). This lectotype is illustrated by figures 3 and 4 on plate 3.

LOCATION OF TYPE.—In the British Museum (Natural History).

METHOD OF IDENTIFICATION.—The genitalia of the lectotype were dissected, studied, and compared with the genitalia of one of the other syntypes by D. S. Fletcher of the Department of Entomology, British Museum (Natural History). This syntype was found to be

the same species as the lectotype and, through the courtesy of A. G. Gabriel, it was sent to me for study. The genitalia of this specimen (illustrated in the present paper by figure 5) together with the photograph of the lectotype (herein illustrated by figures 3 and 4 on plate 3) is the basis for the present identification.

DISTRIBUTION.—Known only from two widely separated areas, Dutch Guiana and Peru.

DUTCH GUIANA: (no specific locality, Fruhsterfer Collection). PERU: Department of Loreto, Iquitos (6036 ft., October). Rio Morona (6203 ft., August).

MATERIAL STUDIED.—Two males and one female, including their genitalia. [Note: The male specimen from Peru is slightly larger and more clearly dull metallic purple, particularly on the forewing, than the one studied from Dutch Guiana. Underneath it has the red markings slightly darker. The eighth tergite and the genitalia of this specimen are somewhat larger. Otherwise it is entirely like the Dutch Guiana specimen.]

6. *Calystryma malta* (Schaus), new combination

FIGURES 6, 16; PLATES 1 (FIG. 9), 2 (FIGS. 8, 9)

Thecla malta Schaus, 1902, Proc. U.S. Nat. Mus., vol. 24, p. 410.—Draudt, in Seitz, 1920, Die Gross-Schmetterlinge der Erde, vol. 5, p. 800; 1921, *ibid.*, vol. 5, p. 829, pl. 158, fig. g [8].—Comstock and Huntington, 1961, Journ. New York Ent. Soc., vol. 69, p. 159.

MALE (pl. 1: fig. 9).—Wings above entirely dark brown, not distinguishable from *C. keta* except that the white submarginal line on hindwing below vein M_3 is very faint. Wings underneath light brown in color as in *C. atrox* and *C. maka* and as in the former with only a single red marginal ocular marking on hindwing. It differs from *C. atrox* in having the black pupil in the center of this ocular marking only slightly smaller and in having slightly more red along inner side of postmedian tripartite line on hindwing.

Length of forewing 13 mm.

Male genitalia as illustrated by figures 6b, c with harpe fused only at base, short and bluntly rounded distally with a small nipple-like projection from dorsal margin at distal end, this projection acute and inwardly directed; aedeagus broadly curved upward throughout the distal three-fourths of its length; gnathal arm distally acute and lacking a carina; with lateral lobe of uncus greatly projected posteriorly into a large, blunt, beaklike lobe and with a minimal projection on lower margin. Eighth tergite (fig. 6A) a simple plate, shallowly incised along posterior margin and with anterior and posterior margins nearly parallel.

FEMALE (pl. 2: figs. 8, 9).—Wings above very much like those of *C. meleager*, darker brown in color with a few orange scales on anal lobe of hindwing and with a distinct marginal line extending from vein 2d A to vein M_3 on this wing. Wings below identical to those of the male except with more red along inner side of tripartite postmedian line on hindwing.

Length of forewing 12 mm.

Female genitalia as illustrated in figure 16 with ductus bursae and bursa copulatrix relatively short, their combined lengths about three times the width of the superior genital plate; the latter with its free edge divided into two lateral elements, each without posterior spurlike processes and composed of a broad lobe and with anterior spurlike process reduced in size and sharply pointed, differing in this last respect from *C. meleager*, which otherwise it most closely resembles.

TYPE-LOCALITY.—Peru (no specific locality).

ADDITIONAL TYPE DATA.—Originally described by Schaus from both sexes with no statement as to the number of specimens. There are in the original series in the United States National Museum four specimens, two males and two females. The first specimen, a male, bears a holograph ink name label with the word "type" in the lower left-hand corner. It also bears the usual USNM red type label with the type number 5929 and a label with the genitalia preparation number WDF 2706. The second specimen, a male without abdomen, bears a holograph ink name label without the word "type" and the USNM red type label with the same type number. The third specimen, a female, bears a holograph ink name label without the word type and lacks a red type number label. This specimen bears a label with the genitalia preparation number WDF 5017. The fourth specimen, a female, bears a holograph ink name label without the word "type" and the same USNM red type label as the first and second specimens mentioned above. It bears also a label with the genitalia preparation number, WDF 5016. It is clear that the first specimen mentioned above, the only one bearing the word "type" on its holograph label is the specimen regarded by Schaus as the type and I therefore designate it the lectotype and have so labeled it. The third specimen mentioned above, a female conspecific with the lectotype, I designate the paralectotype and have so labeled it. The second Schaus specimen mentioned is actually a male of *Calystryma barza*, new species, described later in this paper. The fourth specimen mentioned is a female of an unidentified species not belonging to the genus *Calystryma*.

LOCATION OF TYPE.—As stated above, lectotype male and paralectotype female in the United States National Museum.

DISTRIBUTION.—Known only from Peru, the rather ambiguous type-locality.

MATERIAL STUDIED.—One male and one female including their genitalia. No other specimens are known.

7. *Calystryma anapa*, new species

FIGURES 7, 15; PLATES 1 (FIG. 10), 2 (FIG. 10).

MALE (pl. 1: fig. 10).—Wings above about as in *C. melcager* with the dull metallic purple somewhat darker in hue. Wings underneath with ground color light brown, slightly darker than in *C. malta* and, as in that species, with only a single red marginal ocular marking on the hindwing. It differs from *C. malta* in having the black pupil in the center of this ocular marking very large, taking up over one-half of the area in interspace Cu_1 between the margin and postmedian tripartite line, in having red along inner side of this line more evident, and in having the marginal white line extending further toward costa. The lines at the ends of the cells in both forewing and hindwing are more distinct than in any other species of *Calystryma*.

Length of forewing 15.5 mm.

Male genitalia as illustrated by figures 7B–E with harpe fused only at base, short and bluntly rounded distally with a small nipple-like projection from dorsal margin at distal end, this projection blunt and not inwardly directed; aedeagus broadly curved upward throughout the distal three-fourths of its length, quite similar to *C. malta*; with gnathal arm distally acute and lacking a carina; with lateral lobe of uncus greatly projected posteriorly into a large, blunt, beaklike lobe and with a minimal projection of lower margin. Eighth tergite (fig. 7A) shallowly incised along posterior margin with large blunt posterior lobes and thus more similar to *C. blora* than to *C. malta*. *Calystryma anapa* is distinguished easily from the latter, its nearest relative, in the shapes of the harpe and of the eighth tergite.

FEMALE (pl. 2: fig. 10).—Wings above not different from those of *C. malta*. Wings underneath with slightly lighter brown ground color. Maculation very similar to the male with a smaller black center to the marginal ocular marking of interspace Cu_1 .

Length of forewing 13 mm.

Female genitalia as illustrated by figure 15 with ductus bursae and bursa copulatrix relatively short, their combined lengths about three and one-half times the width of the superior genital plate, the latter with its free edge divided into two lateral elements, each with distinct anterior and posterior spurlike processes that are directed distally.

TYPE-LOCALITY.—Teffé, State of Amazonas, Brazil.

ADDITIONAL TYPE DATA.—Described from the holotype male and allotype female with data as follows: holotype, locality as given above, USNM type no. 24907, no date, Collection Brooklyn Museum, genitalia preparation WDF no. 3178; allotype, "Middle" Rio Ucayali, Department of Loreto, Peru, 6167 ft., Aug. 24, 1928, H. Bassler Collection, genitalia preparation WDF no. 5089.

LOCATION OF TYPES.—Holotype in the United States National Museum. Allotype in the American Museum of Natural History (New York).

DISTRIBUTION.—Known only from the holotype and allotype, which, as mentioned above, are from separate localities in Brazil and Peru.

MATERIAL STUDIED.—One male, one female, including their genitalia.

8. *Calystryma gentilla* (Schaus), new combination, new status

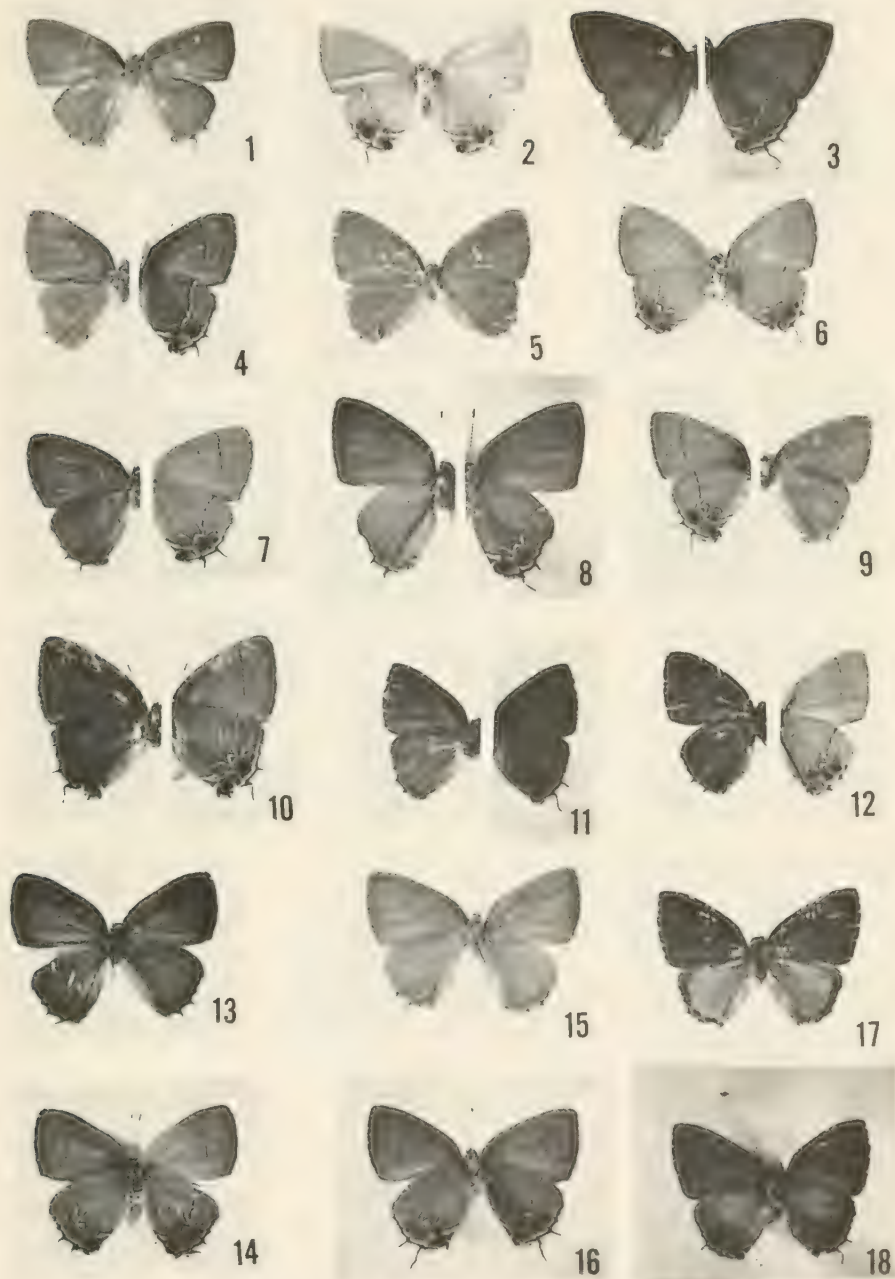
FIGURES 8, 17; PLATES 1 (FIG. 11), 2 (FIGS. 11, 12)

Thecla gentilla Schaus, 1902, Proc. U.S. Nat. Mus., vol. 24. p. 420.—Draudt, in Seitz, 1920, Die Gross-Schmetterlinge der Erde, vol. 5, p. 801; 1921, *ibid.*, vol. 5, p. 828. [For Schaus, 1920, Draudt, 1921, and Comstock and Huntington, 1960, references to *Thecla gentilla* (misidentified), see under *Calystryma atrox*.]

MALE (pl. 1: fig. 11).—Wings above with dull metallic purple ground color, not distinguishable from *C. anapa*. Wings underneath dark brownish gray and as in the latter species with a small red, marginal ocular marking in interspace Cu_1 ; this spot very small, not large as in *C. anapa* and, as in that species, without such a marking in interspace M_3 . Red lunule found inward from marginal bluish spot in interspace Cu_2 small and peppered with black. Red absent along inner side of tripartite postmedian line and with marginal white line very faint above vein Cu_1 .

Length of forewing 12–14 mm.

Male genitalia as illustrated by figures 8B–E with harpes fused only at base; with aedeagus straight except the extreme distal end which is upcurved slightly and thus somewhat similar to that of *C. blora*; gnathal arm distally acute and having a large carina from middle about as in *C. blora* and *C. melcager*; lateral lobe of uncus projected into a small blunt lobe along posterior margin near middle; this lobe not beaklike. Eighth tergite (fig. 8A) cordate in shape, incised along posterior margin, this incision very deep and narrow, distinctly and greatly elongated anteriorly, with posterior lobes blunt and very large and rounded. This tergite thus differs greatly in shape from those of *C. anapa*, *C. naka*, and the other species described above.



FIGURES 1-18.—Males (natural size; spliced figures=upper surface on left, undersurface on right): 1, *Calyptorhynchus keta* Field, upper surface, holotype; 2, undersurface of 1; 3, *C. atrox* (Butler), Rio Marona, Peru; 4, same species, St. Jean, Maroni, French Guiana; 5, *C. blora* Field, upper surface, holotype; 6, undersurface of 5; 7, *C. naka* Field, holotype; 8, *C. meleager* (Druce), Iquitos, Peru; 9, *C. malta* (Schaus), lectotype; 10, *C. anapa* Field, holotype; 11, *C. gentilla* (Schaus), holotype; 12, *C. pisis* (Godman and Salvin), Alhajuela, Panama; 13, *C. barza* Field, holotype; 14, undersurface of 13; 15, *C. tifa* Field, holotype; 16, undersurface of 15; 17, *C. trebula* (Hewitson), Porto Bello, Panama; 18, undersurface of 17.



FIGURES 1-18.—Females (natural size; spliced figures=upper surface on left, underside on right, reversed in fig. 16): 1, *Calystryma keta* Field, "Upper" Rio Maranon, Peru; 2, *C. atrox* (Butler), upper surface, Wismar, British Guiana; 3, underside of 2; 4, *C. naka* Field, allotype; 5, *C. blora* Field, upper surface, Shudihar River, British Guiana; 6, underside of 5; 7, *C. meleager* (Druce), Rio Morona, Peru; 8, *C. malta* (Schaus), upper surface, paralectotype; 9, underside of 8; 10, *C. anapa* Field, allotype; 11, *C. gentilla* (Schaus), upper surface, Igarapi-Açu, Brazil; 12, underside of 11; 13, *C. pisis* (Godman and Salvin), Rio Trinidad, Panama; 14, *C. trebula* (Hewitson), La Florida, Costa Rica; 15, *C. tifla* Field, allotype; 16, same, paratype; 17, *C. cinniana* (Hewitson), upper surface, Port of Spain, Trinidad; 18, underside of 17.



FIGURES 1-4.—Males (twice natural size): 1, *Calystryma atrox* (Butler), upper surface, holotype; 2, underside of 1; 3, *G. meleager* (Druce), upper surface, lectotype; 4, underside of 3.

FEMALE (pl. 2: figs. 11, 12).—Wings above similar to *C. anapa* and *C. malta*, differing in lacking orange on anal lobe and in having the marginal white line very indistinct. Wings underneath slightly lighter in ground color than in the male with black center of marginal ocular marking on interspace Cu_1 smaller than in the male and with an ocular marking faintly indicated on interspace M_3 .

Length of forewing 13 mm.

Female genitalia as illustrated by figure 17 with ductus bursae and bursa copulatrix relatively short, their combined lengths about three and one-half times the width of the superior genital plate; the latter with its free edge divided into two lateral elements with large distally directed posterior spurlike processes, the largest found in the genus, and with smaller but relatively large anterior spurlike processes, which also are directed distally.

TYPE-LOCALITY.—"Petropolis," State of Rio de Janeiro, Brazil.

ADDITIONAL TYPE DATA.—Originally described by Schaus without a statement as to the number of specimens. Since only one specimen in the Schaus Collection of the United States National Museum bears a holograph name label and a red USNM type label with the number 5951, this is the holotype. This specimen also bears a label with the genitalia preparation number WDF 3987. There is a second specimen, a male, in the Schaus Collection with the same locality label as the holotype. I do not consider it a paratype as there is no evidence that Schaus had associated it with the holotype.

LOCATION OF TYPE.—Holotype in the United States National Museum.

DISTRIBUTION.—Known only from the states of Rio de Janeiro and Pará in Brazil.

BRAZIL: State of Rio de Janeiro, Petropolis (no date); State of Pará, Igarapé-Açu (December–February).

MATERIAL STUDIED.—Five males and two females, including their genitalia.

9. *Calystryma pisis* (Godman and Salvin), new combination

FIGURES 9, 23; PLATES 1 (FIG. 12), 2 (FIG. 13)

Thecla pisis Godman and Salvin, 1887, *Biologia Centrali-Americana: Zoology: Insecta: Lepidoptera-Rhopalocera*, vol. 2, p. 84; 1888, *ibid.*, vol. 3, pl. 57, figs. 24, 25 [male].—Draudt, in Seitz, 1920, *Die Gross-Schmetterlinge der Erde*, vol. 5, p. 800; 1921, *ibid.*, p. 830, pl. 158, figs. h [1], h [2].—Comstock and Huntington, 1962, *Journ. New York Ent. Soc.*, vol. 70, p. 115.

MALE (pl. 1: fig. 12).—Wings above dull metallic purple as in *C. anapa* and *C. gentilla*. Wings underneath pale brownish gray with a faint shining yellowish reflection, otherwise with maculation about

as in *C. keta*, with red ocular markings present in both interspace M_3 and Cu_1 on hindwing and with red present along tripartite postmedian line almost to costa.

Length of forewing 13–14.5 mm.

Male genitalia as illustrated by figures 9B–E with harpes fused only at base; with aedeagus nearly straight, except distal end, which is upcurved distinctly, more so than in *C. gentilla*; differing from all other species of *Calystryma* in the shape of the gnathal arm, which is elongated distally, almost needle-like, with carina large, greatly enlarging base of gnathal arm toward its elbow; lateral lobe of uncus similar to that of *C. gentilla* with its posterior lobe broader. Eighth tergite (fig. 9A) cordate in shape, deeply incised along posterior margin with this incision broad and troughlike and thus quite easily distinguished from *C. gentilla*, posterior lobes large, blunt, and concave, not rounded, differing from those of *C. barza*, especially in the greater undulation before distal end of lateral margin, causing the lateral angle to be more pronounced and rounded.

FEMALE.—(pl. 2: fig. 13).—Forewing above dark brown with a slight bluish cast in the basal portion. Hindwing dark brown on costal margin above cell and vein R_s , in extreme base of cell and beyond cell in interspaces M_1 and M_2 . Shining blue in outer portion of cell and between veins M_3 and 2d A. With a white marginal line extending from vein 2d A to M_3 and with marginal dark brown spots in interspaces M_3 and Cu_1 . Anal lobe entirely dark brown. Wings underneath not distinguishable from those of the male.

Length of forewing 13.5 mm.

Female genitalia as illustrated by figure 23 with ductus bursae and bursa copulatrix relatively short, their combined lengths being about three and one-half times the width of the superior genital plate; the latter with its free edge divided into two lateral elements that are each large, rounded, lobelike ridges lacking spurlike processes or any sharp angles.

TYPE-LOCALITY.—Bugaba, Province of Chiriquí, Panama.

ADDITIONAL TYPE DATA.—This species was described by Godman and Salvin from an unspecified number of males from Telemán, Guatemala, Chontales, Nicaragua, and Bugaba, Panama. The Bugaba specimen (collected by Champion) and now in the collection of the British Museum (Natural History), upon which the original colored illustration was based is here designated the lectotype.

METHOD OF IDENTIFICATION.—A toptype matching in every way the maculation of the original colored figure and compared by William Schaus with the original series in the British Museum is the basis for the present identification (fig. 9) of *C. pisis*.

DISTRIBUTION.—From Guatemala south into Panama.

GUATEMALA: Department of Izabal, Cayuga (June, August, September). COSTA RICA: Province of Limón, La Florida (500 ft., March). PANAMA: Province of Chiriquí, Bugaba (no date); Province of Colón, Porto Bello (April), Rio Trinidad (March); Canal Zone, Barro Colorado Island (March), Alhajuela (April).

MATERIAL STUDIED.—Nine males and one female, including their genitalia.

10. *Calystryma barza*, new species

FIGURE 10; PLATE 1 (FIGS. 13, 14)

MALE (pl. 1: figs. 13, 14).—Wings above dark brown as in *C. keta*, *C. atrox*, *C. blora*, and *C. naka*. Wings underneath with ground color pale brown, maculation very much like that of *C. naka* with a great deal of orange red along inner side of tripartite postmedian line, especially in interspace Cu_1 , with slightly smaller black pupils in center of marginal ocular markings of interspace M_3 and Cu_2 and with the marginal blue spot in interspace Cu_2 greatly reduced because of the extension of orange red from the interspaces on either side.

Length of forewing 12.5–13 mm.

Male genitalia as illustrated by figures 10B–E with harpes fused only at base and in lateral view with distal two-thirds of ventral margin very convex and thus differing from all other species of *Calystryma*; with aedeagus nearly straight and distally greatly curved to the insect's left; with gnathal arm acute and upturned at distal end and with carina before middle and small; lateral lobe of uncus slightly and bluntly produced at lower angle with lower margin slightly undulate. Eighth tergite (fig. 10A) similar to that of *C. pisis* with anterior projection broader and indented and with troughlike incision of posterior margin much broader inwardly than at free margin, the posterior lobes thus formed slightly concave along free margin.

FEMALE.—Unknown.

TYPE-LOCALITY.—“Upper” Rio Marañon, Department of Amazonas, Peru.

ADDITIONAL TYPE DATA.—Described from the holotype male and two male paratypes with data as follows: holotype, locality as given above, 6101 ft., Jan. 1, 1925, H. Bassler Collection, genitalia preparation WDF no. 5004; one paratype, Rio Santiago, Department of Amazonas, Peru, 6012 ft., Nov. 30, 1924, H. Bassler Collection, genitalia preparation WDF no. 3157; and one paratype, Collection William Schaus, the paratype of *C. malta* (having its abdomen missing) that is mentioned under the discussion of that species.

LOCATION OF TYPES.—Holotype and one paratype in the American Museum of Natural History (New York), one paratype in the United States National Museum.

DISTRIBUTION.—Known only from Peru.

MATERIAL STUDIED.—Two males, including their genitalia.

11. *Calystryma trebula* (Hewitson), new combination

FIGURES 11, 18; PLATES 1 (FIGS. 17, 18), 2 (FIG. 14)

Thecla trebula Hewitson, 1868, Descriptions of some new species of Lycaenidae, p. 16; 1873, Illustrations of diurnal Lepidoptera, Lycaenidae, vol. 1, p. 146; 1873, *ibid.*, vol. 2, pl. 57, figs. 363, 364.—Godman and Salvin, 1887, *Biologia Centrali-Americana: Lepidoptera-Rhopalocera*, vol. 2, pp. 84, 85.—Godman, in Godman and Salvin, 1901, *Biologia Centrali-Americana: Lepidoptera-Rhopalocera*, vol. 2, p. 720.—Dyar, 1914, *Proc. U.S. Nat. Mus.* vol. 47, p. 149.—Draudt, in Seitz, 1920, *Die Gross-Schmetterlinge der Erde*, vol. 5, p. 801; 1921, *ibid.*, p. 831, pl. 158, figs. h [8] h [9].—Hoffmann, 1940, *An. Inst. Biol.*, vol. 11, p. 717.—Comstock and Huntington, 1964, *Journ. New York Ent. Soc.*, vol. 72, p. 176.

MALE (pl. 1: figs. 17, 18).—Forewing above very dark brown, hindwing bright iridescent blue except for a border of dark brown around outer margin that is just over one millimeter in width. It thus differs from all other species of *Calystryma*. Wings underneath bright yellowish brown, thus also differing from all other species of *Calystryma* on this surface. Maculation most similar to that of *C. blora* except that red coloration on hindwing is more distinctly red and the elements of the white marginal line on this wing are convex instead of being more straight, outlining the outer edge of blue spot in interspace Cu_2 and the black pupillated red ocular markings in interspaces M_3 and Cu_1 .

Length of forewing 11.5–13 mm.

Male genitalia as illustrated by figures 11B–E with harpes fused only at base; with aedeagus slightly upcurved from near middle, otherwise straight; with gnathal arm blunt and slightly upturned at distal end and with carina small and arising from near distal end causing gnathal arm to be nearly bifurcate in appearance and thus differing from all other species of *Calystryma*; lateral lobe of uncus much less produced than in the other species and with lower margin slightly concave. Eighth tergite (fig. 11A) similar to that of *C. pisis* and *C. barza* with anterior projection narrow and rounded, not indented, with troughlike incision of posterior margin only slightly broader anteriorly than at free margin and with posterior lobes slightly rounded, not concave along free margin.

FEMALE (pl. 2: fig. 14).—Forewing dark brown except for a few blue scales below vein 2d A in basal one-half of wing. Hindwing bright shining blue except for a dark brown border, about one millimeter in width around outer margin, this border broken into separate but nearly confluent dark brown spots in interspaces M_3 , Cu_1 , and Cu_2 . Marginal white line present in these same interspaces. Anal lobe lacking red. Wings underneath similar in all respects to those of the male except with the marginal ocular markings slightly smaller on the hindwing.

Length of forewing 11–12 mm.

Female genitalia as illustrated by figure 18 with ductus bursae and bursa copulatrix relatively short, their combined lengths just over three and one-half times the width of superior genital plate; the latter with its free edge divided into two lateral elements, each with two strongly developed spurlike processes, about equal in size and distally directed.

TYPE-LOCALITY.—Teffé ("Ega"), State of Amazonas, Brazil.

ADDITIONAL TYPE DATA AND LOCATION OF TYPE.—This species was described by Hewitson from a single specimen, the holotype male (in the collection of H.W. Bates), now in the collection of the British Museum (Natural History) and labeled with the type number Rh. 955.

METHOD OF IDENTIFICATION.—The original description, the original colored illustrations, and a specimen compared by William Schaus with the holotype are the basis for the present identification of the name *C. trebula*.

DISTRIBUTION.—Widely spread over the American tropics from Mexico south to Brazil and Peru.

MEXICO: State of Vera Cruz, San Rosa (April). GUATEMALA: Department of Izabal, Cayuga (May). COSTA RICA: Province of San José, Guapiles (850 ft., May); Province of Limón, La Florida (500 ft., March). PANAMA: Province of Chiriquí, Chiriquí (no date); Province of Bocas del Toro, Bocas del Toro (April); Province of Colón, Porto Bello (April), Río Trinidad (March); Canal Zone, Barro Colorado Island (March). COLOMBIA: Department of Cauca, Jalima (no date). PERU: Department of Loreto, Achinamiza (6001 ft., September). BRAZIL: State of Amazonas, Teffé (no date).

MATERIAL STUDIED.—Twenty-seven males and two females, including their genitalia.

12. *Calystryma tifa*, new species

FIGURES 12, 19; PLATES 1 (FIGS. 15, 16), 2 (FIGS. 15, 16)

MALE (pl. 1: figs. 15, 16).—Wings above entirely dark brown as in *C. barza*, *C. keta*, and the other brown-colored species of *Calystryma*. Wings underneath with ground color pale brown, paler than in *C. naka*, about as in *C. barza* and with maculation differing from the latter only in having the marginal blue spot of interspace Cu_2 on hindwing larger and the white marginal line on this wing more distinct.

Length of forewing 13 mm.

Male genitalia as illustrated by figures 12B–E with harpes fused only at base and unique in shape both in lateral and in ventral views, being bifurcate in ventral view and showing a large spurlike projection from dorsal margin near distal end in lateral view; with aedeagus extremely long and distinctly upcurved distally; with gnathal arms acute and broadly and evenly bent upward, without carina; with

lateral lobe of uncus having a greatly projected beaklike lobe on posterior margin and with lower margin convex. Eighth tergite (fig. 12A) similar to that of *C. trebula* and with anterior projection narrow and extended, with incision of posterior margin shallow and broad forming posterior lobes that are slightly acute laterally along free margin.

FEMALE (pl. 2: figs. 15, 16).—Forewing dark brown except for two rays of shining blue, one in base of wing below 2d A and the other along base of cell. Hindwing mostly shining blue in color, very much as in females of *C. trebula* with dark border becoming more narrow toward costa instead of broader as is true in that species and also as in *C. trebula* with this border broken into separate but nearly confluent dark brown spots in interspaces M_3 , Cu_1 , and Cu_2 . There are a few red scales on anal lobe and there is a bluish-white marginal line below vein M_3 extending to vein 2d A. Wings underneath identical to those of the male.

Length of forewing 10.5–12 mm.

Female genitalia as illustrated by figure 19 with ductus bursae and bursa copulatrix relatively short, their combined lengths only about three times the width of the superior genital plate; the latter with its free edge divided into two lateral elements each with both posterior and anterior spurlike processes that are reduced and about equal in size and with the anterior spurlike process sharply pointed and the posterior one blunt.

TYPE-LOCALITY.—Achinamiza, Department of Loreto, Peru.

ADDITIONAL TYPE DATA.—Described from the holotype male, allotype female, and one female paratype with data as follows: holotype, locality as given above, 6001 ft., Oct. 30, 1927, H. Bassler Collection, genitalia preparation WDF no. 5005; allotype, same data as holotype except genitalia preparation WDF no. 5081, paratype, same data except collecting date in Jan. 3, 1936, and genitalia preparation WDF no. 5084.

LOCATION OF TYPES.—Holotype and allotype in the American Museum of Natural History (New York), paratype in the United States National Museum.

DISTRIBUTION.—Known only from the type-locality in Peru.

MATERIAL STUDIED.—One male and two females, including their genitalia.

13. *Calystryma cinniana* (Hewitson), new combination

FIGURE 20; PLATE 2 (FIGS. 17, 18)

Thecla cinniana Hewitson, 1877, Illustrations of diurnal Lepidoptera, Lycaenidae, vol. 1, p. 189; vol. 2, pl. 75, figs. 593, 594 [female].—Druce, 1907, Proc. Zool. Soc. London, 1907, p. 622.—Draudt, in Seitz, 1920, Die Gross-Schmetterlinge der Erde, vol. 5, p. 805; 1921, *ibid.*, p. 827; 1922, *ibid.*, pl.

159, figs. f [3], f [4].—Comstock and Huntington, 1959, Journ. New York Ent. Soc., vol. 67, p. 187.

Calycopis cinniana (Hewitson).—Kaye, 1914, Trans. Ent. Soc., London, 1913, p. 570; 1921, Catalogue of Trinidad Lepidoptera: Rhopalocera, Mem. Dept. Agric., Trinidad and Tabago, no. 2, p. 94.

MALE.—The male is said by Druce (Proc. Zool. Soc. London, 1907, p. 622) to differ from the female in having the costal half of the uppersurface of the hindwing dark brown. I have been unable to find males I could associate with the two females identified as *C. cinniana* below.

FEMALE (pl. 2: figs. 17, 18).—Forewing entirely dark brown except for a few blue scales on base of vein 2d A. Hindwing shining pale blue, much paler in hue than in the other species of the genus and with this color covering a larger area than in the other species so that this wing is almost entirely pale blue except for dark brown on anal lobe and for a tiny and faint marginal dark brown spot on interspace Cu₁ and a faint bluish-white marginal line between 2d A and vein M₁. Fringe at margin dark brown, outward from margin bluish white. Wings below pale brown, paler than in other species of the genus except *C. tifla* and much warmer in hue than in that species.

Length of forewing 10 mm. The smallest species in the genus.

Female genitalia as illustrated by figure 20 with ductus bursae and bursa copulatrix very short, the shortest of any species of *Calystryma*, the combined length being only about two and one-half times the width of the superior genital plate; the latter with its free edge divided into two lateral elements, with posterior spurlike processes lacking and anterior spurlike process greatly reduced and with the posterior margin between these spurlike processes greatly produced posteriorly (and thus differing from all other species of *Calystryma*).

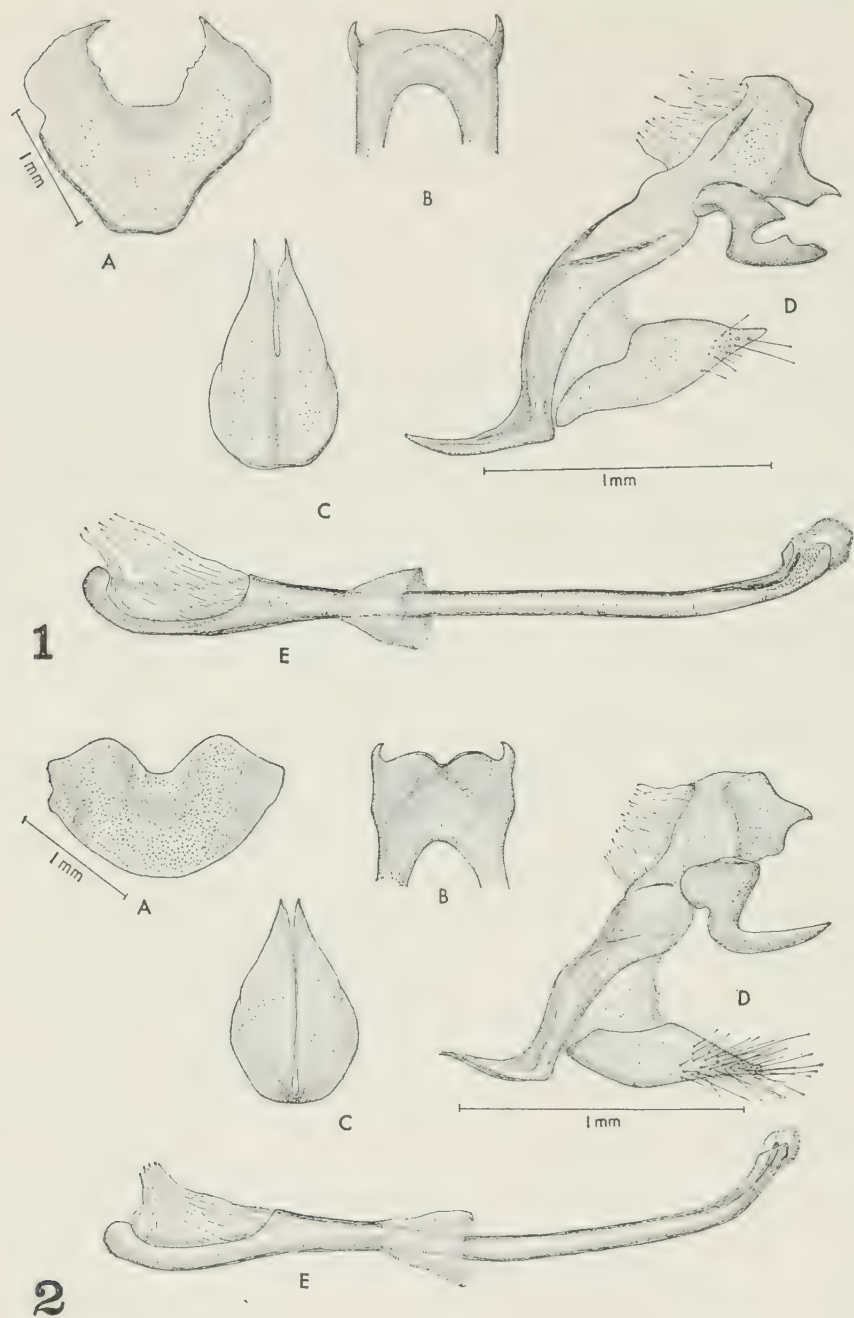
TYPE-LOCALITY.—“The Amazon,” Brazil.

METHOD OF IDENTIFICATION AND LOCATION OF TYPE.—This species was described by Hewitson from a single female specimen from the Henley G. Smith Collection now in the British Museum (Natural History). A specimen from Cayenne, French Guiana, comparing favorably with the original colored illustration identified by William Schaus as *C. cinniana* after comparison with the type specimen, is the basis for the present identification. The color and maculation of both surfaces of the hindwings cannot be confused with any other species.

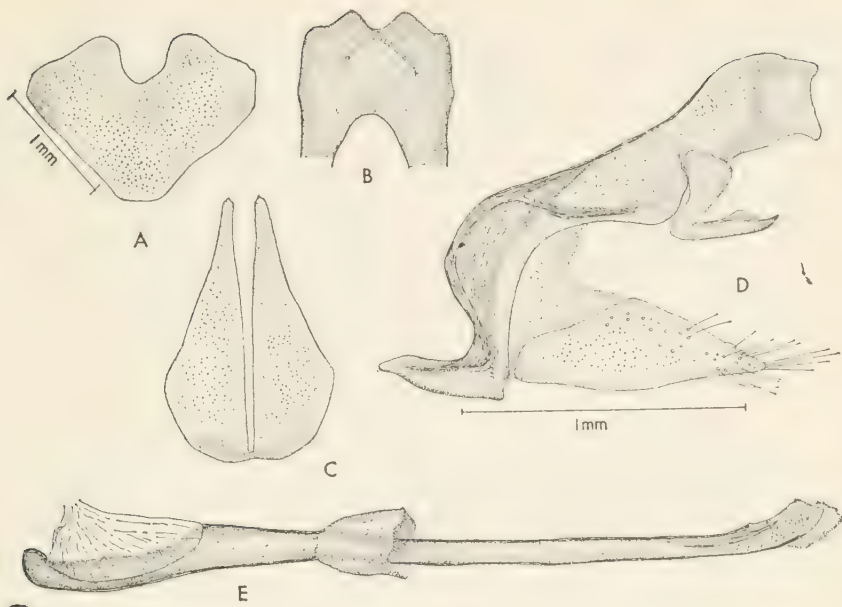
DISTRIBUTION.—From Trinidad and French Guiana to the Amazon River in Brazil.

TRINIDAD: St. George County, Port of Spain (April). FRENCH GUIANA: Colony of Guiana, Cayenne (no date). BRAZIL: state?, the Amazon (no date).

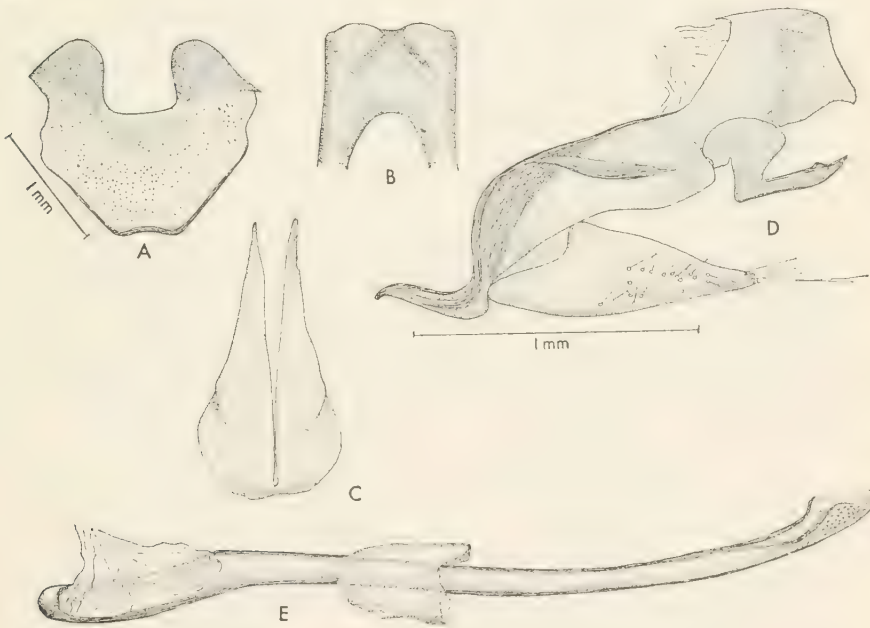
MATERIAL STUDIED.—Two females, including their genitalia.



FIGURES 1, 2.—Male genitalia and 8th tergite of male abdomen: 1, *Calystryma keta* Field, holotype; 2, *C. atrox* (Butler), from prep. 3160 WDF. (A=8th tergite; B=uncus and gnathos in dorsal view; C=harpes in ventral view; D=left half of harpe, tegumen, uncus, vinculum, and saccus in lateral view; E=aedeagus in lateral view.)

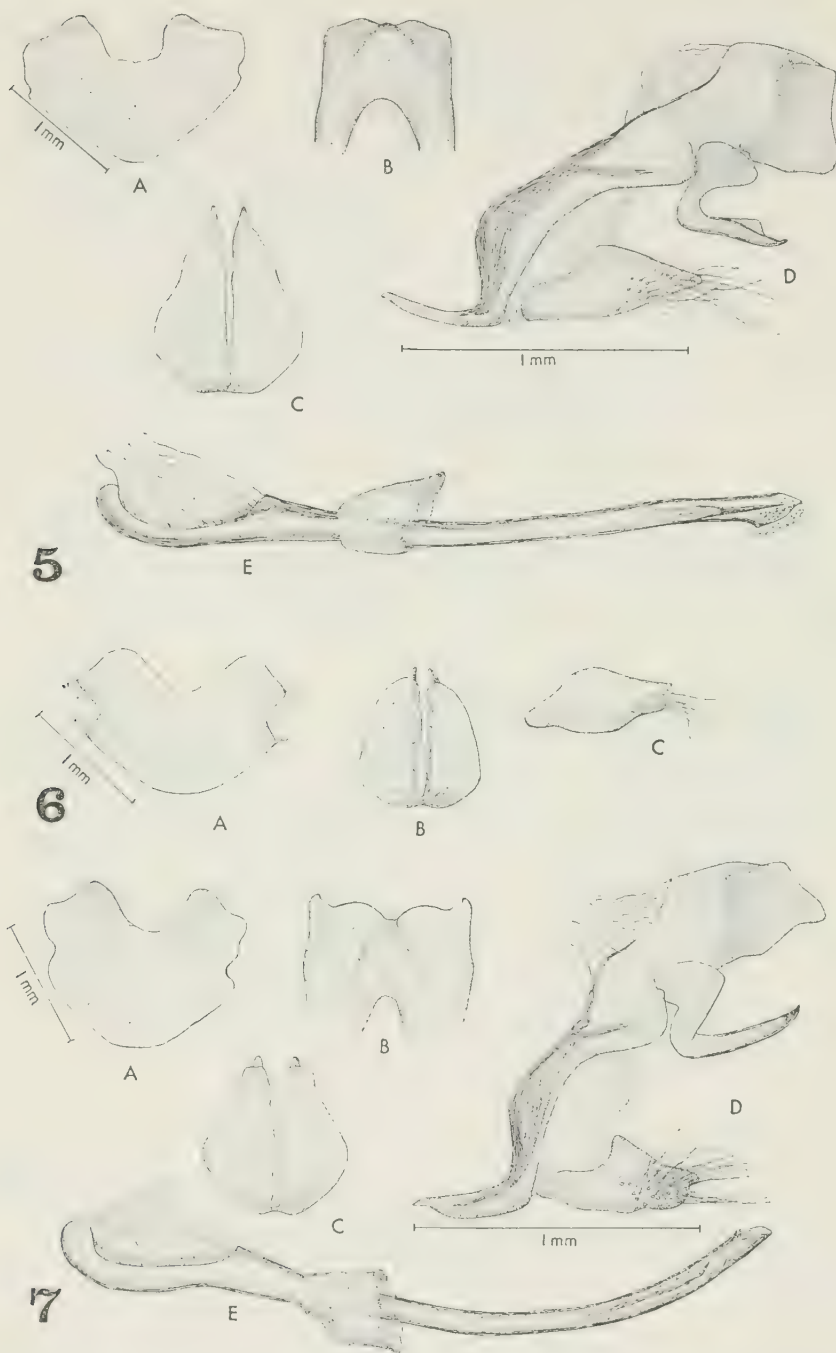


3

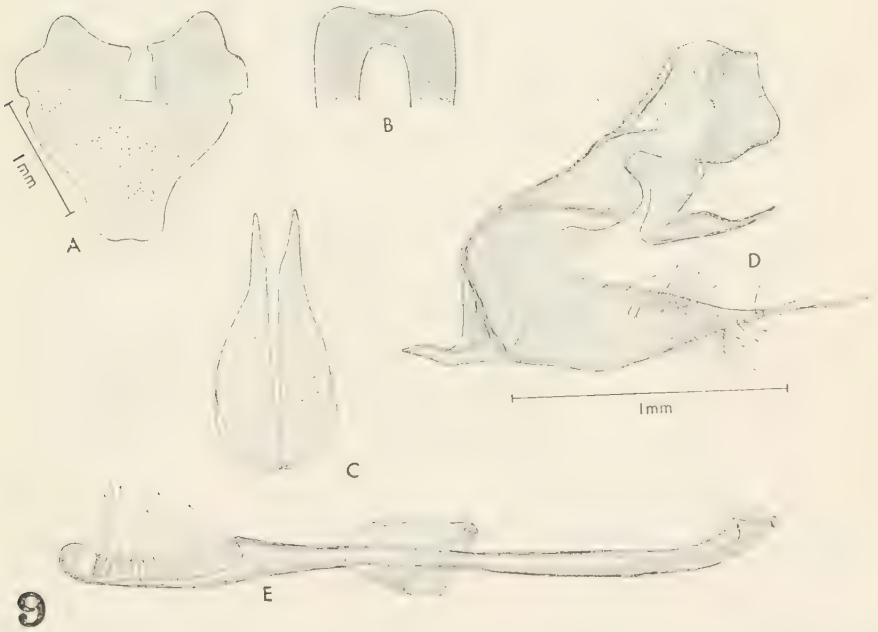
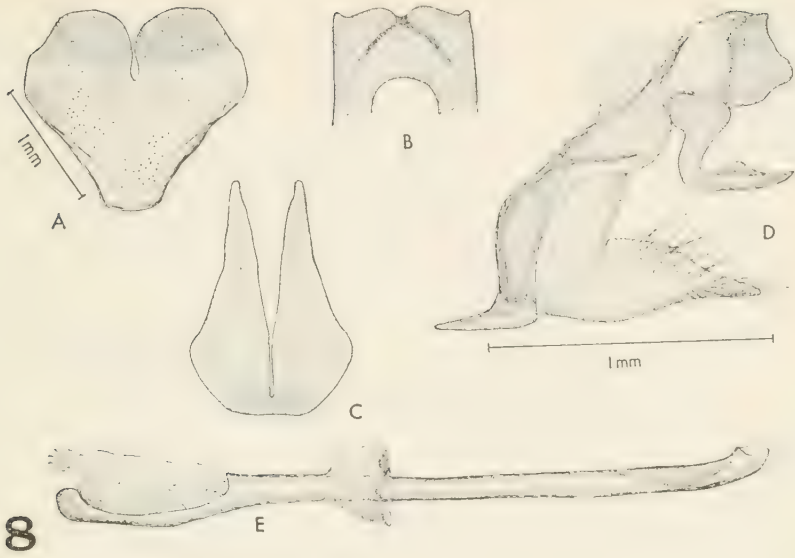


4

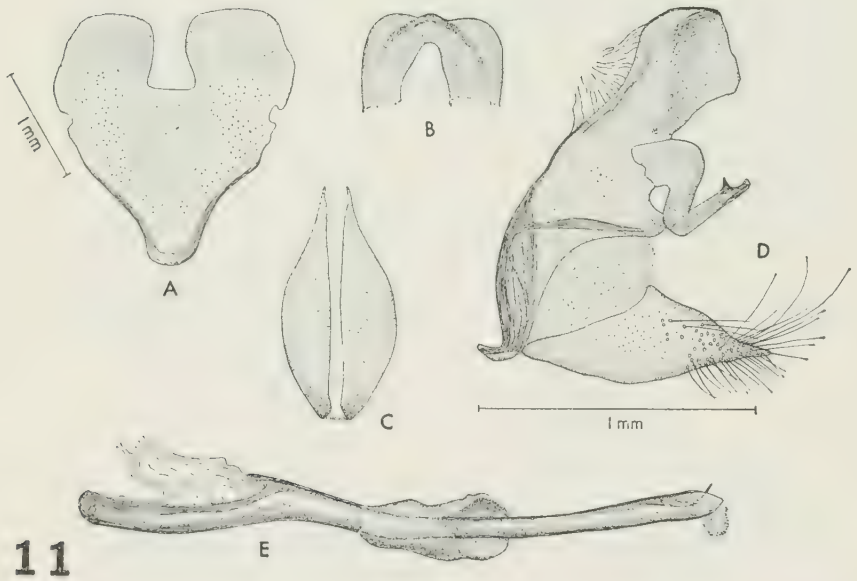
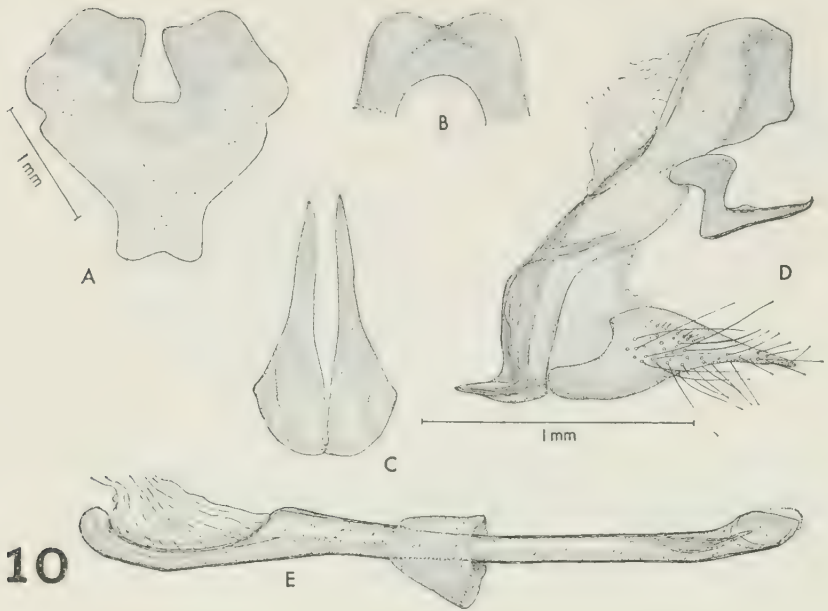
FIGURES 3, 4.—Male genitalia and 8th tergite of male abdomen: 3, *C. blora* Field, holotype; 4, *C. naka* Field, holotype. (Same key as figs. 1, 2.)



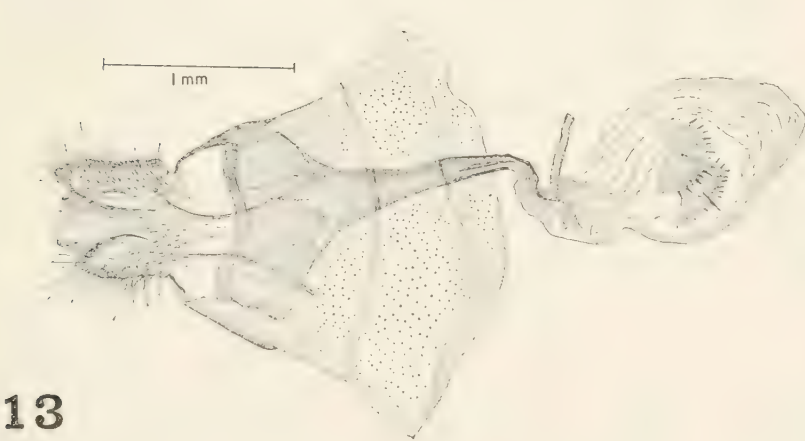
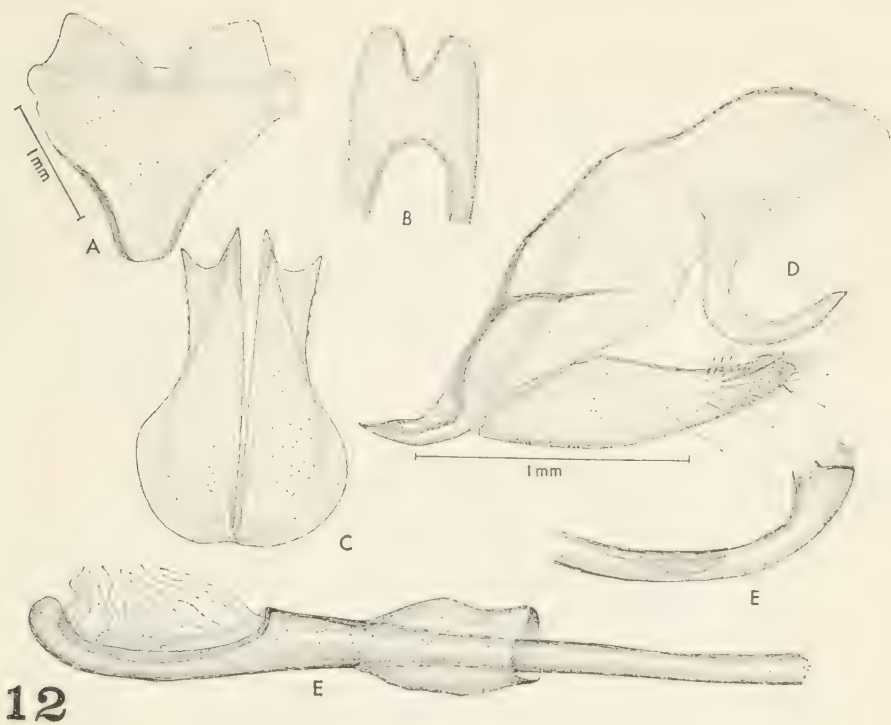
FIGURES 5-7.—Male genitalia and 8th tergite of male abdomen: 5, *C. meleager* (Druce), from prep. BM 1951 498; 7, *C. anapa* Field, holotype (same key as figs. 1, 2). Parts of male genitalia and 8th tergite of male abdomen: 6, *C. malta* (Schaus), lectotype (A=8th tergite; B=harpes in ventral view; C=left harpe in lateral view).



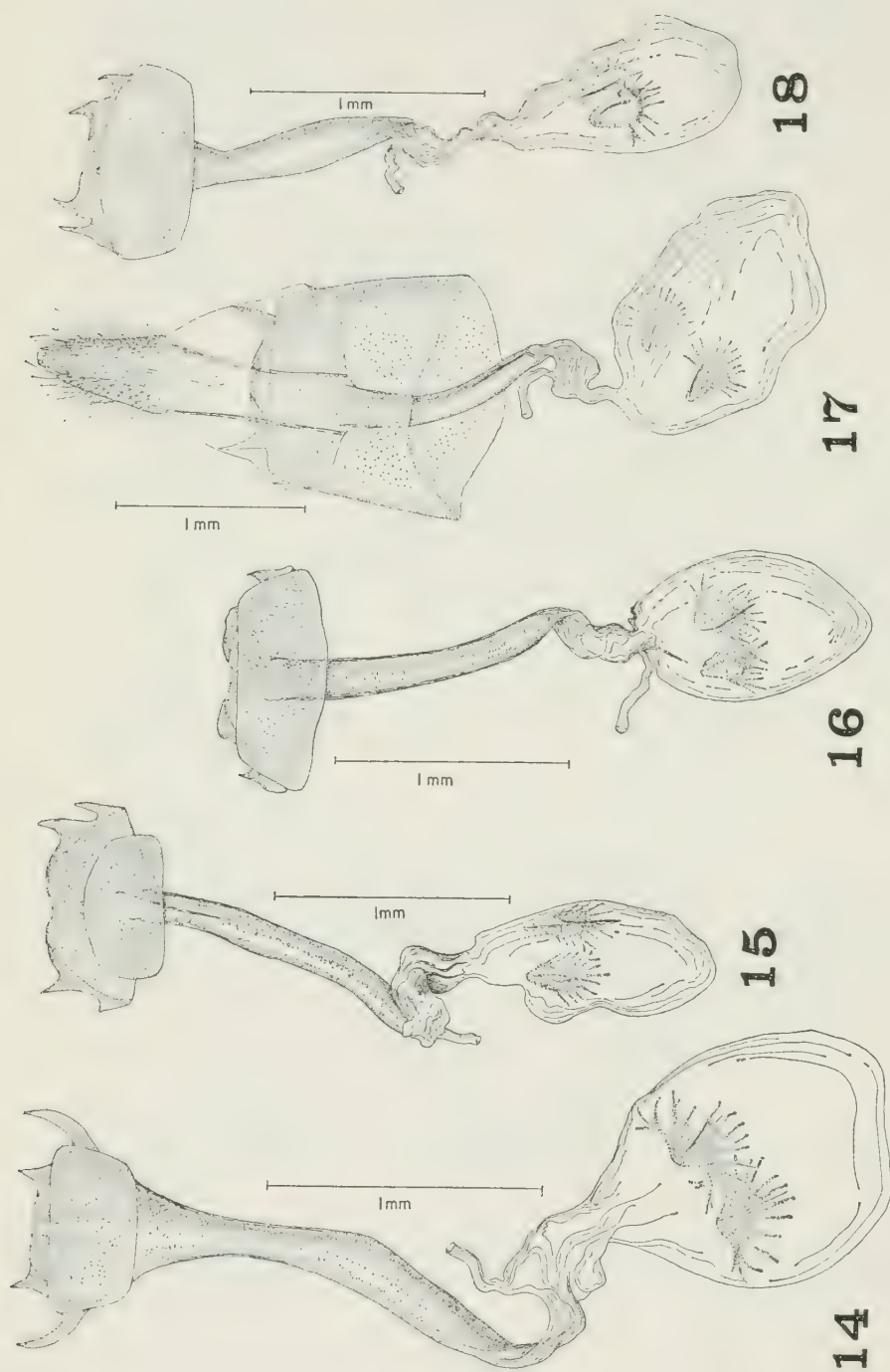
FIGURES 8, 9.—Male genitalia and 8th tergite of male abdomen: 8, *C. gentilla* (Schaus), holotype; 9, *C. pisis* (Godman and Salvin), from prep. 5035 WDF. (Same key as figs. 1, 2.)



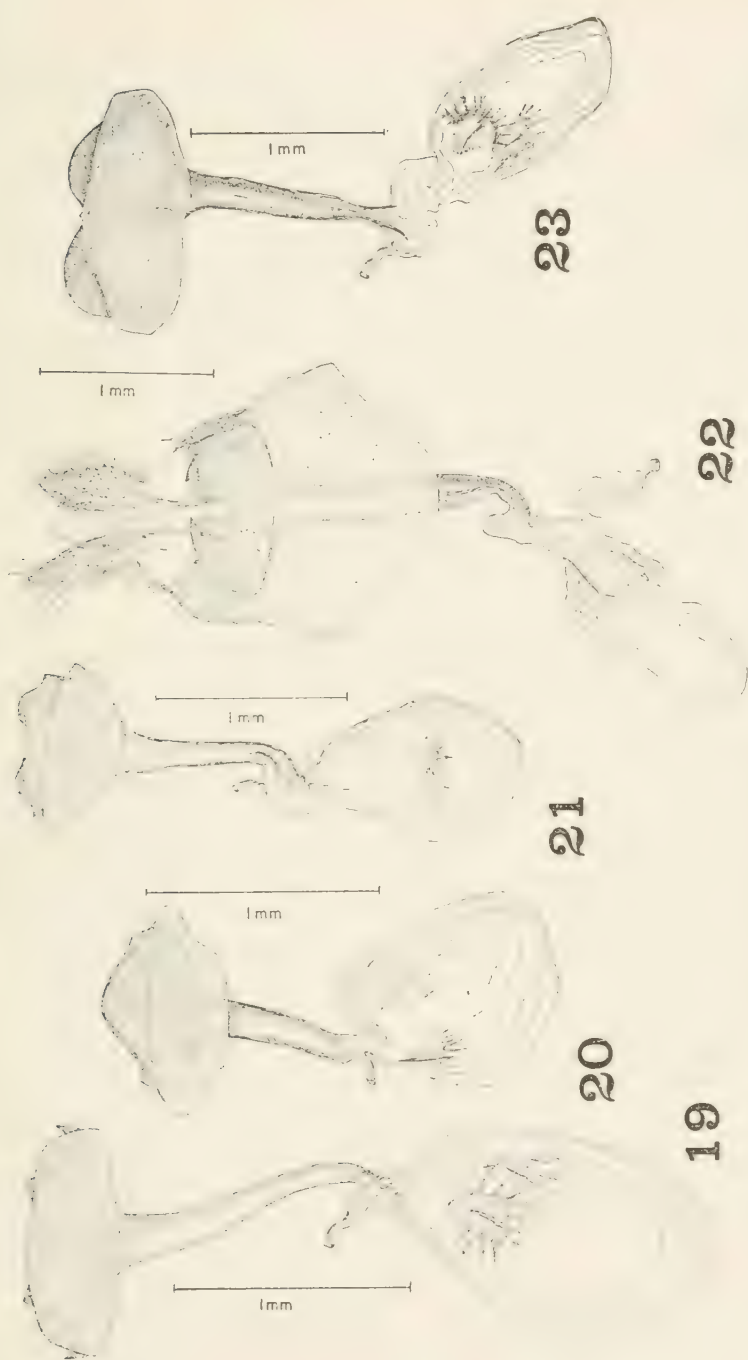
FIGURES 10, 11.—Male genitalia and 8th tergite of male abdomen: 10, *C. barza* Field, holotype; 11, *C. trebula* (Hewitson), from prep. 5039 WDF. (Same key as figs. 1, 2.)



FIGURES 12, 13.—Male genitalia and 8th tergite of male abdomen: 12, *C. tiffa* Field, holotype (same key as figs. 1, 2). Female genitalia in ventral view: 13, *C. atrox* (Butler), from prep. 5072 WDF.



FIGURES 14-18.—Female genitalia in ventral view (ovipositor shown only in fig. 17): 14, *C. keta* Field, from prep. 5086 WDF; 15, *C. anapa* Field, allotype; 16, *C. malta* (Schaus), paralectotype; 17, *C. gentilla* (Schaus), from prep. 5088 WDF; 18, *C. trebula* (Hewitson), from prep. 5047 WDF.



FIGURES 19-23.—Female genitalia in ventral view (ovipositor shown only in fig. 22): 19, *C. tifa* Field, allotype; 20, *C. cinniana* (Hewitson), from prep. 5082 WDF; 21, *C. melager* (Druce), from prep. 5090 WDF; 22, *C. naka* Field, allotype; 23, *C. pisis* (Godman and Salvin), from prep. 5046 WDF.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3612

A Review of the Valbyteuthidae And an Evaluation of its Relationship With the Chiroteuthidae (Cephalopoda: Oegopsida) ¹

By Clyde F. E. Roper and Richard E. Young ²

Joubin (1931) described from the Bay of Panama an unusual squid, *Valbyteuthis danae*, which possessed such distinctive characters that he placed it in a new family. He aligned this family, the Valbyteuthidae, with the Chiroteuthidae and Brachioteuthidae. Since the original description, no additional specimens of this family have been reported in the literature; Robson (1948, p. 127), however, briefly described, as *Chiroteuthis*, a small specimen that appears to be *Valbyteuthis*. Thiele listed the Valbyteuthidae in his systematic handbook (1935).

The extensive cephalopod collections currently being studied at the Institute of Marine Science of the University of Miami contain a number of specimens of *Valbyteuthis*. This material was captured over a broad geographic area including the type-locality. Examination of the material indicates that *Valbyteuthis* does not warrant inclusion in a separate family, a fact that necessitates a re-evaluation of the systematic position of the group.

¹ Contribution No. 790 from Institute of Marine Science, University of Miami, and Paper No. 60 from *Dana* Oceanographic Collections. This work was supported by research grants GA-253 and GB-1090 from the National Science Foundation.

² Roper: Division of Mollusks, U.S. National Museum; Young: Institute of Marine Science, University of Miami, Fla.

The original description is based upon a specimen captured in the Bay of Panama during the *Dana* Expedition (1920–1922). The present material includes *Dana* specimens, one of which was taken at the third station following the capture of Joubin's holotype. In addition, material is utilized from the following sources: United States Antarctic Research Program, USNS *Eltanin*; Inter-American Tropical Tuna Commission, M/V *Shoyo Maru*; Woods Hole Oceanographic Institute, R/V *Chain*; and University of Southern California, R/V *Velero* iv. The authors are grateful to Dr. E. Bertelsen of the Carlsburg Foundation, the U.S. Antarctic Research Program of the National Science Foundation, Dr. Klawe of the Inter-American Tropical Tuna Commission, Dr. R. H. Backus of Woods Hole Oceanographic Institute, and Mr. R. Lavenberg of the University of Southern California for making these specimens available for study.

We would like to thank Dr. Gilbert L. Voss for his interest and encouragement during our studies and for his review of the manuscript. We also gratefully acknowledge Miss Constance Stolen for her excellent preparation of the illustrations.

Family CHIOTEUTHIDAE Gray

VALBYTEUTHIDAE Joubin, 1931, p. 188.—Thiele, 1935, p. 971.

Valbyteuthis Joubin

Valbyteuthis Joubin, 1931, p. 188.—Thiele, 1935, p. 971.—Young and Roper, in press.

Chiroteuthis.—Robson, 1948, p. 127.

DIAGNOSIS.—A chiroteuthid with elongate ventral arms, oval funnel-mantle locking apparatus. Antitragus present, tragus absent. Short, compact tentacular club with suckers in four rows. Club suckers on short stalks. Broad, round, subterminal fins; length 60 percent of width. Photophores absent. Funnel valve absent.

The material examined is as follows:

vessel and station no.	location	mantle length (mm)	estimated depth of capture (m)
<i>Eltanin</i> 34	07°45'N 81°37'W	47	683
<i>Eltanin</i> 52	16°30'S 74°36'W	35	1162
<i>Eltanin</i> 741	40°16'S 78°18'W	31	2635
<i>Eltanin</i> 743	33°18'S 72°27'W	30	1830
<i>Dana</i> 3980 IX	23°26'S 03°57'E	38	1500
<i>Dana</i> 1206 v	06°40'N 80°47'W	34	1250
<i>Dana</i> 1370 XIII	36°36'N 26°14'W	31	1500
<i>Dana</i> 1171 XII	08°19'N 44°35'W	21	1000
<i>Dana</i> 1203 XII	07°30'N 79°19'W	25	1250
<i>Dana</i> 1208 VII	06°48'N 80°33'W	19	1000
<i>Dana</i> 4003 IV	08°26'S 15°11'W	24	1500
<i>Dana</i> 4014 III	28°09'N 15°19'W	11	450
<i>Dana</i> 4158 XIV	46°28'N 08°01'W	12	2000

essel and station no.	location	mantle length (m)	estimated depth of capture (m)
Chain 35-958	09°17'N 49°04'W	55	530
Shoyo Maru 8	39°12'S 106°48'W	35, 34, 33	<i>Alepisaurus</i> stomach
Shoyo Maru 7	40°09'S 109°38'W	34	<i>Alepisaurus</i> or alba- core stomach
Scot 77	14°12'N 92°47'W	15	300
Velero IV-10265	33°18'N 118°40'W	33, 26, 25	1200

Valbyteuthis danae Joubin

Valbyteuthis danae Joubin, 1931, p. 188.—Thiele, 1935, p. 971.

DESCRIPTION.—This description is based only upon material captured in the region of the type-locality (Elt. 34; *Dana* 1206 v, 1203 xii, 1208 vii). Measurements are given on page 5. The mantle is short and broad; the muscular portion tapers rapidly posteriorly and terminates beneath the anterior third of the fins. Only the integument continues posteriorly over the gladius. The mantle wall is thin but muscular (pl. 2b).

Fins are huge and extremely muscular; their length is about 50 percent of the mantle length and their width is about 80-85 percent of the mantle length. The anterior lobes are attached to the dorso-lateral sides of the mantle. The attached borders of the anterior fin lobes are clearly visible beneath the integument and form a broad V. The posterior border of each fin is indented slightly at the midline; the lateral margin is semicircular in outline (pl. 2A).

The gladius has a long, narrow, extremely delicate rhachis. The short, thin vane arises abruptly near the anterior level of the fins, folds rapidly ventrally, and fuses in the midline to form a long, slender conus. The walls of the conus are much heavier than the anterior portion of the gladius. The conus is rectangular in cross-section and is broken just posterior to the fins. The terminal portion has been lost in all specimens; it is apparent, however, from the large diameter and heavy construction of the conus that *Valbyteuthis* possesses a long tail (pl. 2c).

The funnel is large and narrow and reaches the level of the middle of the eyes. The funnel component of the locking apparatus is oval and deeply concave, particularly at the posterior end, where the depression tends to undercut the lateral margin. A distinct antitragus is present on the posterior wall of the funnel component. The mantle component is [human] nose shaped, with the tip directed posteriorly. The component also curves laterally to conform to the deep lateral depression of the funnel component. A small indentation that locks with the antitragus is located beneath the tip at the posterior end of the mantle component (pl. 4A,B).

The dorsal member of the funnel organ is broadly triangular in outline, with only a small posterior indentation. A spatulate papilla

arises from the anterior apex. The ventral members are large and oval. No trace of a funnel valve exists (pl. 4c).

The head is elongate; toward the anterior end it bears large protruding eyes that are directed slightly forward. The "olfactory" organs are situated posterior to the eyes on long, slender stalks. Nuchal crest and nuchal folds are lacking. Two heavy, muscular bridles extend from the cephalic cartilage along the ventral surface of the head and attach to the dorsolateral sides of the tubular portion of the funnel. The cephalic vein lies close to the surface in the midline between the bridles (pls. 1c, 2b).

The arms are weak and slender and arranged in the order $4 \cdot 3 = 2 \cdot 1$. The dorsal three pairs of arms bear biserially arranged suckers throughout their length. In some specimens, the ventral row of suckers of these arms possesses two to four moderately enlarged suckers located about two-thirds of the distance along the length of the arm. Probably this represents a sexual dimorphism, but because the specimens are insufficiently developed, the sexes cannot be determined in all cases. The sucker stalks are short and arise from large, conical bases. The chitinous rings are large but possess very small apertures that bear approximately 7-10 (average 8) short, broad, truncate teeth that are separate along the distal half of the margin. In the proximal half, the teeth are fused, giving a smooth margin that becomes slightly scalloped laterally (pl. 4k-n). The dorsal three pairs of arms appear to bear low keels, particularly along the distal portions. The arms, however, have been injured so that the true nature of the keels is difficult to determine. Protective membranes are developed weakly and, although they are not supported by distinct trabeculae, their margins are scalloped.

The ventral arms are extremely long, slender, and fragile and have large lateral membranes that extend their full length. The suckers originate in two rows at the base of each ventral arm but gradually tend to converge into a single row near the middle of the arm. These suckers are extremely small and decrease in size toward the middle portion of the arm, where they disappear, leaving the distal half of the arm naked. No protective membranes or trabeculae occur on arms iv.

Tentacles are long and slender; they bear very short, simple clubs. Keels are not apparent. The protective membranes form an indistinct ridge and trabeculae are indistinguishable (pl. 1d). The carpal area bears approximately four to five small suckers that alternate in two longitudinal rows. The outer chitinous rings of these suckers are narrow bands. The inner rings have three superimposed rows of small, rounded knobs; the outer row bears about 15 knobs. The smaller knobs of the inner rows alternate with those of the outer row

(pl. 4H). The suckers of the manus and dactylus are arranged in four uniform, longitudinal rows, except at the tip, where only one or two suckers remain. The suckers have broad, flat outer chitinous rings. The inner rings have very small apertures and lack dentition (pl. 4I, o).

The buccal membrane possesses seven buccal lappets. The buccal membrane connectives attach dorsally to arm pairs one and two and ventrally to arm pairs three and four. The oral surface of the buccal membrane is covered with distinct, closely set longitudinal ridges and grooves.

A few irregularly scattered, brown chromatophores are present on the mantle, fins, head, and arms.

The beaks are illustrated on plate 4, figures D-F. The rostrum of the upper mandible is short and has a sharply pointed tip; the palatine lamella is short and broad. The rostrum of the lower beak is short and triangular and has dorsolateral ridges on the hood. A weak lateral ridge is present on the gular lamella.

The radula consists of seven rows of teeth in a transverse series. The rhachidian tooth has a very slender, elongate, median cusp and two lateral cusps that frequently bear a small medial bump. The first lateral tooth has a long, medial cusp and two small lateral cusps; the smaller and more medial of these is somewhat variable in size but provides the first lateral tooth with a distinctive and unusual feature. The second lateral tooth has a broad base and bears a single, long, slender cusp. The lateralmost tooth has an extremely elongate, curved cusp. Marginal plaques are lacking in *Valbyteuthis* (pl. 4G).

Measurements in mm of two specimens of *Valbyteuthis danae* Joubin from the region of the type-locality (Bay of Panama) are as follows:

	<i>Ellanin 34</i>		<i>Dana 1206 v</i>	
sex	male		?	
mantle length	47		34	
mantle width	16		12	
head length	21		14	
head width	16		12	
fin length	25		17	
fin width	40		29	
arm length	right	left	right	left
I	20	21	8*	13
II	22	25	14	15
III	—	26	17	15*
IV	43	37*	25	27
tentacle length	81	78	36	37
club length	7½	7	4	4½

*Marks indicate that tip of arm is missing.

DISTRIBUTION.—Figure 1 shows the distribution of the genus *Valbyteuthis*, which was recorded previously only from the type-locality, 07°30'N, 79°19'W. The genus is now known to occur throughout the Atlantic Ocean from about 25°S to 46°N and in the Eastern Pacific Ocean from about 40°S to 35°N. The longitudinal range is from 04°E to 120°W. We do not suggest that these are the distributional limits of the genus.

The distributional map refers to the genus *Valbyteuthis* and not to *V. danae*. It is evident from our specimens that at least two species occur other than *V. danae*, but formal recognition of them must wait until further material becomes available.

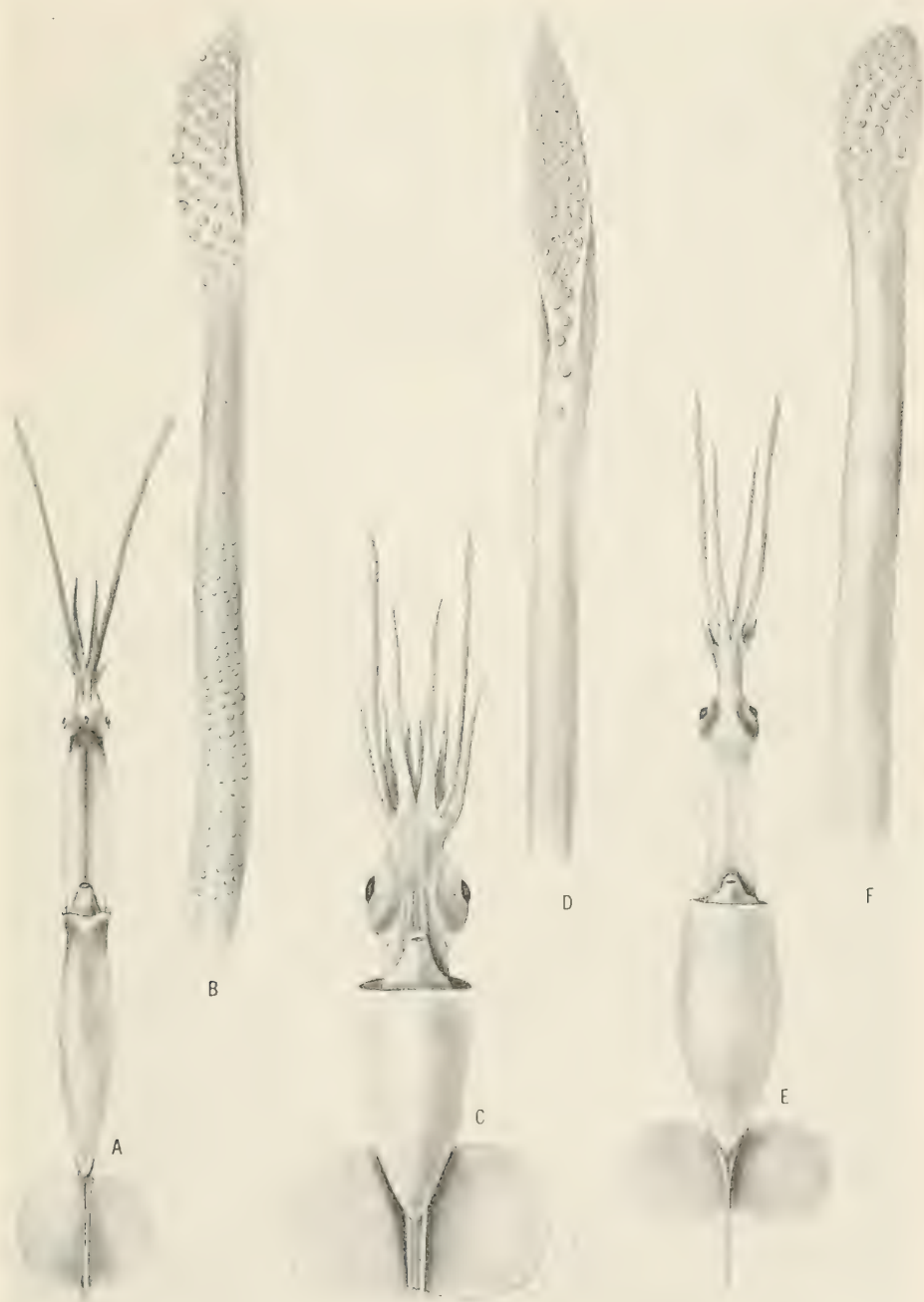
Discussion

On the basis of the material available to us, it is possible to re-evaluate the status of the Valbyteuthidae. Numerous characteristic features are possessed by *Valbyteuthis* that clearly demand that its familial ranking be submerged and that the genus be placed in the Chiroteuthidae sensu stricto. The most important of these features are discussed below.

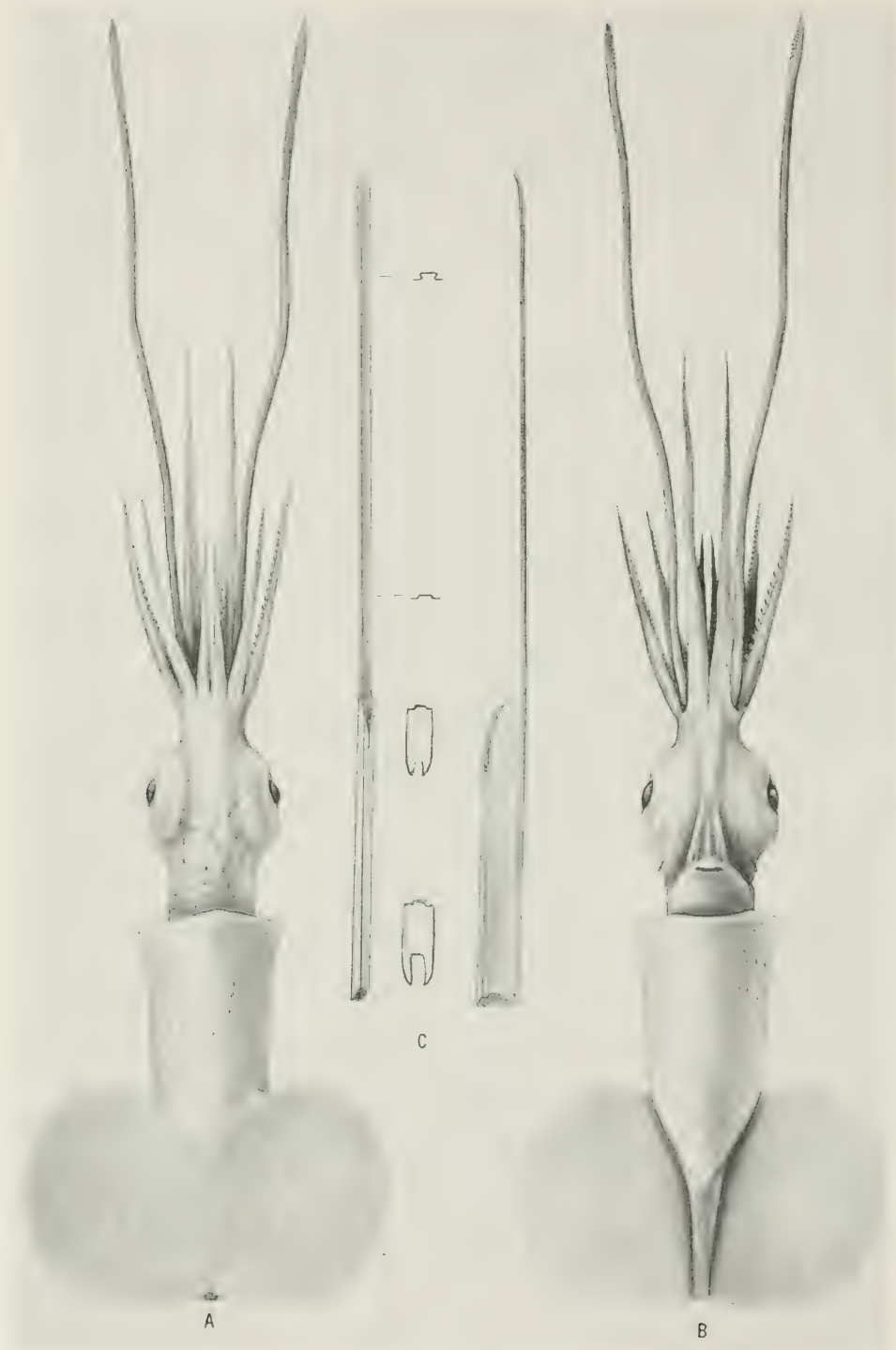
The connectives of the buccal membrane of *Valbyteuthis* are attached to the dorsal sides of arms one and two and to the ventral sides of arms three and four. The gladius consists of a long, narrow rhachis and a vane that folds ventrally until the edges fuse in the ventral midline to form a long, slender conus. These features align *Valbyteuthis* with the Chiroteuthidae and a number of related families (see Young and Roper, in press, for a more detailed discussion).

The closely related families Mastigoteuthidae and Chiroteuthidae possess distinctive funnel-mantle locking apparatuses. The funnel components of these structures are oval and bear one or two protuberances (tragus and antitragus) that give them an ear-shaped appearance. This characteristic locking mechanism is not found in other families. Joubin (1931) described and illustrated the locking apparatus of *Valbyteuthis* as oval but without protuberances and stated that it was not ear shaped. Our specimens, including those from the type-locality, possess a well-developed antitragus on the posterior wall of the funnel component. Although this differs from *Chiroteuthis* by lacking a tragus, it unquestionably falls within the chiroteuthid-mastigoteuthid pattern. Joubin's failure to observe this structure is partly responsible for his incorrect systematic placement of *Valbyteuthis*.

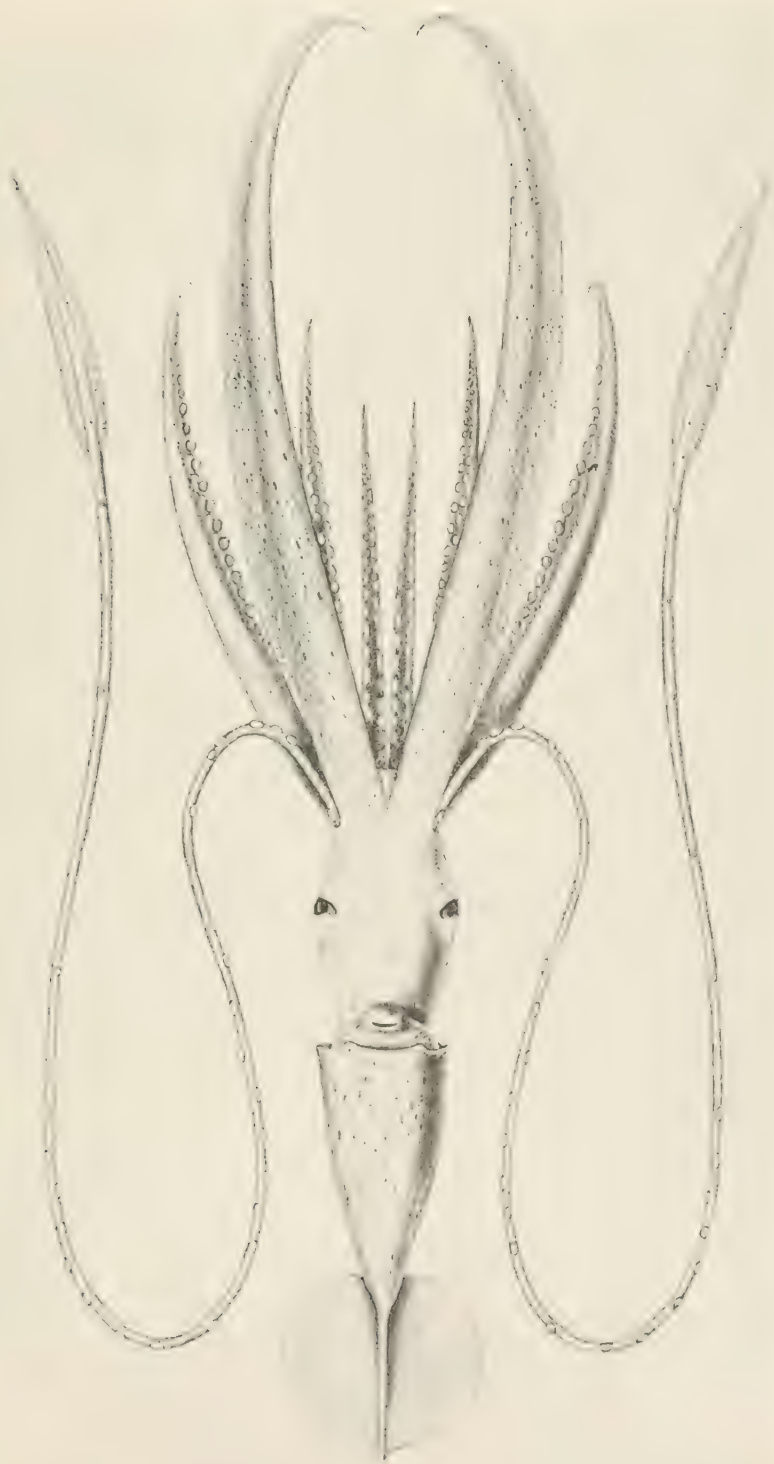
Probably the most distinctive feature of *Valbyteuthis* that could be used to substantiate its position in an independent family is the peculiar structure of the tentacular clubs. These clubs are unlike those found in any adult chiroteuthid. They are, however, nearly



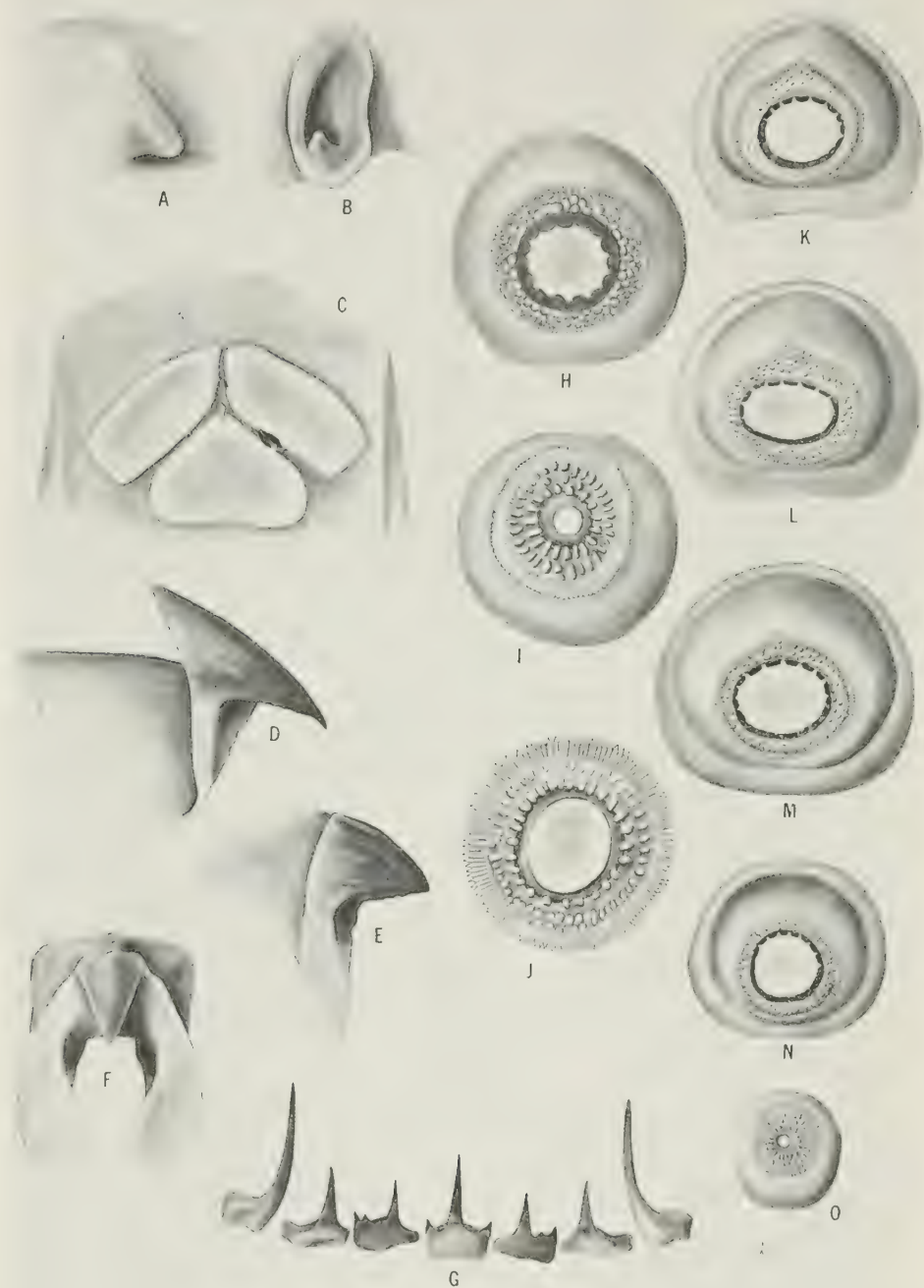
Chiroteuthis: A, "doratopsis" stage, 32 mm mantle length (ML) (modified from Pfeffer, 1912, pl. 46: fig. 4); B, "doratopsis"-type tentacle showing larval club distally and developing adult club on stalk, 28 mm ML, *Dana* 1157 II. *Falbyteuthis danae*: C, ventral view, 34 mm ML, *Dana* 1206 V; D, adult tentacular club, 47 mm ML, *Elt.* 34. *Falbyteuthis* species: E, ventral view of larva, 15 mm ML, *Scot* 77; F, larval tentacular club, 15 mm ML, *Scot* 77.



Valbyleuthis danae, 47 mm ML, *Elt.* 34: A, dorsal view; B, ventral view; C, ventral and lateral views of galdius with cross sections.



Chiroleuthis species, 63 mm ML, *Felero* 9349: ventral view (this species has a "doratopsis"-type larva).



Valbyteuthis danae, 47 mm ML, *Ell.* 34: A, B, mantle and funnel components of locking apparatus; D-F, upper and lower mandibles; G, radula; H, sucker from carpus; I, sucker from manus enlarged; K-N, suckers from arms I-IV; O, sucker from manus (K-O=identical enlargement). 35 mm ML, *Ell.* 52: C, funnel organ. *Chiroteuthis*, "dorstopis"-type larva, 28 mm ML, *Dana* 1157 II: J, sucker from manus.

identical with the early larval clubs of *Chiroteuthis*, the predominant genus of the family. The adult *Chiroteuthis* club begins to develop in the larval stage along the tentacular stalk proximal to the primary larval club. The primary larval club is eliminated upon metamorphosis either by resorption or autotomy (pers. observ.). The striking similarity of clubs of *Valbyteuthis* and early larval *Chiroteuthis* is apparent in the illustrations on plate 1B, D, and F, and indicates the close relationship of the two genera.

Further relationship between these genera is suggested by the close resemblance of the extremely long, weak, ventral arms; they



FIGURE 1.—Geographic distribution of *Valbyteuthis*.

bear small suckers that are aligned nearly in a single row, and they possess very large lateral membranes. These features give the arms a very distinctive appearance. The characteristic lateral membranes were not mentioned in Joubin's description and did not appear in his illustration, probably due to the poor condition of his specimen.

Although the adults of the two genera appear to differ considerably in overall appearance (pls. 2A, B, 3), general similarities do exist. In addition to the characteristics already mentioned, both groups have elongate heads, oval fins, and similar arm formulae.

The larval stages of *Valbyteuthis* and *Chiroteuthis* (especially the "doratopsis" type) show even greater similarities, particularly in the following details: very elongate head, long fourth arms, relatively

short tentacles, simple clubs, long tail, superficial position of cephalic vein and funnel bristles, spindle-shaped liver, and absence of photophores (pl. 1A, E). The two larval forms can be distinguished only by close examination. As the "doratopsis" develops, the adult club begins to form on the tentacular stalk, light organs appear on the viscera, eyes, ventral arms, and tentacles, and the head begins to shorten. At metamorphosis, the tentacles become greatly elongated; the early larval club is lost, and the body proportions change.

As the larval *Valbyteuthis* develops, only a few changes occur, of which the shortening of the head is the most noticeable. Even though our large specimens are not sexually mature, no evidence of an impending metamorphosis exists, and it is clear that these specimens represent the adult form and are not oversized larvae. Therefore, while *Chiroteuthis* undergoes considerable change during development, *Valbyteuthis* remains approximately at the "doratopsis" stage.

The above discussion reveals that *Valbyteuthis* closely resembles *Chiroteuthis*. The similarities are particularly strong between *Valbyteuthis* and the larval "doratopsis" stage of *Chiroteuthis*. Therefore, although these two genera are clearly distinct, it is not possible to maintain the more recently described family, the Valbyteuthidae, as a distinct taxon, and it is placed herein in the synonymy of the family Chiroteuthidae.

Summary

Valbyteuthis danae Joubin, 1931 is redescribed based on *Dana* and *Eltanin* material from the type-locality.

The known distribution of the genus *Valbyteuthis* extends in the Eastern Pacific from 40° S to 35° N and throughout the Atlantic from 25° S to 46° N.

The family Valbyteuthidae is submerged in the family Chiroteuthidae, primarily on the basis of the similarities between *Valbyteuthis* and certain larval chiroteuthids ("doratopsis" type). *Valbyteuthis* remains a distinct genus.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3613

Two New Crustaceans: The Parasitic Copepod
Sphaeronellopsis monothrix (Choniostomatidae)
And its Myodocopid Ostracod Host
Parasterope pollex (Cylindroleberidae)
From the Southern New England Coast

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The parasitic copepods of the family Choniostomatidae have received little attention since the classic monograph of Hansen (1897). This neglect is probably attributable to the fact that the majority of them inhabit the marsupia of other crustaceans, mostly Peracarida, where they easily are mistaken for the eggs of the hosts and therefore are overlooked. The abundance of the new choniostomatid considered in this paper suggests that these copepods are more common than generally is realized.

The new choniostomatid described herein, *Sphaeronellopsis monothrix*, was discovered by Kornicker during a study of a new species of ostracod, *Parasterope pollex*, from Hadley Harbor, near Woods Hole, Mass. The description of *P. pollex* has been prepared by Kornicker alone, while that of *S. monothrix* is the work of both authors.

The material available has been sufficient to enable us to give some details of the biology of *S. monothrix* and its relations with the host. Following this account are formal taxonomic descriptions of both species.

The station data for the collections of ostracods used in this study are as follows:

station	locality	date/time	depth m	P. pollex number per sample
1907	Hadley Harbor, Woods Hole, Mass. block 137	July 13, 1965 0945 hrs.	1	63
2906	Hadley Harbor, " block 111	July 7, 1965 1440 hrs.	2	170
Coll. 1	Lake Tashmoo, Martha's Vineyard, Mass.	Nov. 13, 1962		1
Coll. 2	Lake Tashmoo, "	Nov. 13, 1962		1
Coll. 4	Lake Tashmoo, "	Nov. 13, 1962		
-	Great Harbor, Woods Hole, Mass.	Sept. 12, 1962	5	1
260	Hadley Harbor, "	Apr. 27, 1965	1-2	44
270	Hadley Harbor, "	May 4, 1965	1	4
276	Hadley Harbor, "	May 25, 1965	1	95
2207	Hadley Harbor, "	July 13, 1965	6	4
1	Stonewall Pond, Chilmark, Martha's Vineyard, Mass.	July 1965	2	27
6	Stonewall Pond, Chilmark, "	July 1965	3	9
7	Lagoon Pond, Vineyard Haven, "	July 1965	2	10

We are grateful to Dr. Roland L. Wigley, Bureau of Commercial Fisheries Biological Laboratory, Woods Hole, Mass., for ostracods from Great Harbor and Lake Tashmoo; to Mr. J. Stewart Nagle, Marine Biological Laboratory, Woods Hole, for ostracods from Hadley Harbor, and to Mrs. C. R. Stoertz, Department of Paleobiology, Smithsonian Institution, for ostracods from stations 1, 6, and 7 from Martha's Vineyard. We thank Mrs. Carolyn Bartlett Gast for final preparation of the ostracod figures from camera lucida drawings by Kornicker.

LIFE HISTORY OF *Sphaeronellopsis monothrix*.—From the specimens in our collections (p. 3) it is possible to reconstruct some details of the life history. It is obvious from the account that follows that our knowledge of many phases of the life history is either fragmentary or completely lacking. We hope that the ready availability of the species at Woods Hole and perhaps elsewhere on the Atlantic Coast will lead others to investigate more intensively the biology of this interesting parasite.

The motile stage by which *Sphaeronellopsis* spreads from one ostracod to another is the copepodid, which swims by means of the 2 pairs of flat, setose trunk legs. Copepodids found in an ostracod marsupium without accompanying adult copepods or ovisacs are interpreted as recently having invaded the hosts. Since they do not differ in size or morphology from copepodids still within the ovisac membrane, there appears to be only one copepodid instar. The copepodid normally does not enter immature ostracods; we have not found any infestation in female ostracods less than 1.30 mm long.

Spermatophores were attached to 2 female copepods, .23 and .36 mm in length, indicating that mating may take place when the female is very young or may be delayed until she is older. Only 3 male

copepods were found, suggesting that the life span of the male is much less than that of the female.

Ostracods that already have laid a clutch of eggs are not attacked. The only parasitized ostracod with its own eggs in its marsupium was a specimen containing copepodids. The susceptible period for the ostracod is the time following its final molt and preceding egg deposition. Once it is in the marsupium, the presence of the copepod inhibits egg laying by its host. Only 1 female *Sphaeronellopsis* develops in an ostracod, but more than 1 male may be found in a single host.

Sphaeronellopsis eggs are not laid singly, but in groups, each of which is enclosed by a membrane. All the eggs in 1 ovisac are at the same developmental stage, but those in different ovisacs may be in different stages. We have divided the eggs arbitrarily into 3 categories, according to the stage of development (pl. 1*d-f*; list below): spherical eggs, pyriform eggs, and copepodids still within the ovisac membrane. Several batches of eggs must be laid at intervals, since ovisacs with all 3 stages may occur together. Each ovisac contains about 15 eggs, and up to 8 ovisacs (about 120 eggs) in one stage have been found in an ostracod. The total number of eggs produced by a female must be at least 3 x 120 or 360, and perhaps more, since it is possible that more than 3 clutches of eggs are laid.

DATA ON SPECIMENS OF *Sphaeronellopsis monothrix* (the 3 types of ovisacs are shown in pl. 1*d-f*). —

sex of ostracod host	station	copepods			number of ovisacs		
		length of female	number of males	number of copepodids	spherical	pyriform	copepodid
♀ a	1907			2			
♀	"	.36			8	4	
♀	"	.32				2	2
♀	"	.39			3	3	1
♀	"	.35		5		7	1
♀	"	.33				2	2
♀	"	.37			2		1
♀	"	.33	1		5		
♀	"	.34				1	2
♀	"	.40	2	1	5	4	
♀	"	.40			7		
♀	"	.36 ^b			5	3	
♂	"			1			
♀	2906	.40			6		
♀	"	.36					
♀	"	.30					
♀	"	.24					
♀	"	.30					

See footnotes at end of table.

sex of ostracod host	station	length of female	copepods		number of ovisacs		
			number of males	number of copepodids	spherical	pyriform	copepodid
♀	2906	.47					
♀	"				5		
♀	"				3		
♀	"	.25					
♀	"	.42					
♀	"			2	3		
♂	"	.33					
juv. ♂	Coll. 4	.23 ^b					

^a Ostracod eggs present.

^b Spermatophore attached.

INCIDENCE OF PARASITISM.—In spite of the similarity in size, the female *Sphaeronellopsis* and her ovisacs are readily distinguishable from ostracod eggs thru the valves of undissected preserved specimens. The female *Sphaeronellopsis* has a characteristic yellow color, and her ovisacs are less uniform in appearance than ostracod eggs. The smaller and more transparent copepodids are more difficult to see altho some were visible in intact ostracods. No male copepods were discovered in undissected ostracods.

Specimens appearing to have parasites were examined after being cleared in glycerine to be rendered more visible. To increase the reliability of the search, additional ostracods in which copepods had not been seen in the preliminary examination were also examined in glycerine, but this supplementary examination revealed very few additional parasites. In all, 86 ostracods were examined in glycerine, and in about half of these the shell was removed.

Of the 407 ostracod specimens, including juveniles and adults, 25, or nearly 1 out of 16, were found to be parasitized. Since juveniles normally are not parasitized (all of the 95 juveniles from station 276 were free of copepod parasites), the degree of infestation of adults is more significant biologically. Our most reliable data is from the station 2906 collection of 170 ostracods, which includes about 141 adult females (15 with marsupial eggs), 6 adult males, and 23 juveniles. Ten of the females and 1 of the males were parasitized, i.e., about 1 out of 13 adults. The success of the parasitism is evident when it is considered that the copepod eggs being brooded by the ostracods outnumber their own eggs. A female *Parasterope* seldom has more than 13 eggs in her marsupium, less than the number in 1 copepod ovisac.

HOST SPECIFICITY.—*Sphaeronellopsis monothrix* has been found only in *Parasterope pollex*. One other myodocopid ostracod, *Sarsiella zostericola*, is abundant in Hadley Harbor; 17 specimens, including 8 adult females, 1 adult male, and 8 juveniles have been examined for sphaeronellids with negative results. It is noteworthy that in

collections from Lyttleton Harbor, New Zealand, Hansen (1905) found *Sphaeronellopsis littoralis* in *Sarsiella hispida* but not in the much more abundant *Sarsiella hanseni*.

EFFECTS OF PARASITISM ON THE HOST.—We have observed no differences between parasitized and nonparasitized ostracods in the structure of the shell or the body and its appendages. As Hansen (1897) has pointed out, choniostomatids apparently feed by piercing the host's integument with pointed mandibles and sucking its blood with the aid of the funnel-shaped mouth cone. The effect of this feeding on the ostracod is unknown. The most serious effect of the *Sphaeronellopsis* appears to be the inhibition of ovulation by the host. Only 1 of the 23 parasitized female ostracods had laid its own eggs in its marsupium. Conversely, the copepod seems to be deterred from entering the marsupium of an ostracod that is incubating its own eggs; 16 of the 17 ostracods with their own eggs in their marsupia were not parasitized.

These observations are similar to those of Hansen (1897), who reported that in studying the 38 species of choniostomatids living in crustacean marsupia, he found almost 160 cases of marsupia with parasites and no host eggs, but only 6 cases wherein parasites and host eggs occurred together.

EGG MIMICRY IN THE CHONIOSTOMATIDAE.—The similarity in size of *Sphaeronellopsis* ovisacs and the eggs of the ostracod host is more than coincidental. While the individual *Sphaeronellopsis* eggs are much smaller (diameter about .07 mm) than the ostracod eggs, they are grouped into clusters of about 15 eggs; the diameter of the clusters usually falls between .20 and .30 mm, about the same as that of the ostracod eggs. This similarity in size clearly seems to be a case of egg mimicry having adaptive value for the *Sphaeronellopsis*. The 3rd thoracic legs of myodocopid ostracods are very flexible, adapted for removing foreign particles from the interior of the valves and from the eggs (Skogsberg, 1920, p. 88, ftn.). Individual copepod eggs presumably would be removed from the brood chamber by the cleaning leg, but the copepod avoids this hazard by laying its eggs in groups within sacs, each sac mimicking 1 of the ostracod eggs in size and shape. Instead of being removed as a foreign particle, the *Sphaeronellopsis* ovisac is retained within the brood chamber and cleaned by the host with the same solicitude given to its own eggs. To a male ostracod, however, an ostracod egg or a *Sphaeronellopsis* ovisac mimicking an ostracod egg is a foreign particle and therefore is removed by the cleaning leg. It is significant that in the few instances in which a female *Sphaeronellopsis* was found in a male ostracod, no ovisacs were present.

Altho 38 of the 43 species dealt with by Hansen in his classic 1897 monograph inhabit the marsupia of Amphipoda, Isopoda, Cumacea, and Mysidacea, Hansen did not call attention to the similarity in size between the eggs of the host and the ovisacs of the choniostomatid parasites. The above peracarid crustaceans aerate and keep their eggs free of contaminating particles by circulating a current of water thru the marsupium by movements of the pleopods (gammaridean Amphipoda), maxillipeds (Isopoda, Cumacea), or oostegites (Tanaidacea, Isopoda, caprellid Amphipoda). There is no flexible appendage that can reach into the marsupium and handle the eggs individually, except possibly in the Mysidacea (Jancke, 1924); hence, mimicry of the eggs of these Crustacea is not needed to prevent them from ejecting the eggs of their choniostomatid parasites. Individual copepod eggs, however, because of their small size, would be in danger of being flushed from the marsupium by the circulating water current, whereas ovisacs similar in size to the host's eggs are too large to encounter this risk. Thus it is advantageous to the choniostomatid to lay its eggs in groups rather than singly.

A further advantage to the parasite in having its ovisacs resemble the host's eggs is that the parasitized host does not become more conspicuous and thus more vulnerable to predators than in the normal ovigerous condition. This advantage only operates when the marsupial contents are visible, and is probably much less significant in ostracods, in which the shell obscures the eggs, than in crustaceans with transparent oostegites. Della Valle (1893) pointed out that the ovisacs of species of *Sphaeronella* infesting the amphipods *Ampelisca diadema* and *Microdeutopus gryllotalpa* matched the color of the host's eggs. This predator-deceiving egg mimicry, to be distinguished from the host-deceiving egg mimicry in *Sphaeronellopsis monothrix*, is also characteristic of marsupial parasites that are too large or firmly attached to be dislodged by the host. Crytoniscid isopods (species summarized recently by Nielson and Stromberg, 1965) are in this category. Whether the host behaves normally in ventilating and cleaning the contents of its marsupium when it is occupied by a predator-deceiving parasite instead of its own eggs is not known.

Sphaeronellopsis Hansen, 1905

Sphaeronellopsis monothrix Bowman and Kornicker, new species

FIGURES 1-3

FEMALE.—Length .23-.47 mm. Head well defined from trunk, relatively large. Trunk wider than long in fully developed female, narrower than long in young female, ventral surface with a number of rows of minute hairs. Submedian skeleton of head well developed;

longitudinal bar on each side, divided posteriorly, has strong bar extending laterad between 2nd maxilla and maxilliped; focusing shows this lateral bar to be folded as it passes anteriorly and reaches base of 2nd maxilliped.

1st antenna 2-merous; proximal segment long, well provided with setae as shown in figure 1*b*, bearing distally a long esthete; 2nd segment short, with 2 apical setae. 2nd antenna absent. 1st maxilla with 2 processes, directed anteriorly and laterad. 2nd maxilla apparently 2-merous; proximal segment robust with row of surface spinules, produced distally into lobe overlapping medial surface of distal segment; distal segment with apex ending in 2 teeth. Maxilliped 3-merous; 1st segment without ornamentation; 2nd segment with short blunt distal spine; distal segment short, conical, entire.

Legs and caudal rami composed of single short cylindrical segment bearing a single terminal seta with swollen base.

Boundaries of genital area not evident. Genital apertures broadly U-shaped, located lateral to and slightly anterior to caudal rami. Seminal receptacles oval.

MALE.—Length .11 to .13 mm. Body chunky, about $\frac{7}{8}$ as broad as long and nearly $\frac{3}{4}$ as high as long. Head somewhat more than $\frac{1}{2}$ total body length; anterior margin smoothly rounded, lateral margins evenly convex; greatest width at level of bases of 2nd maxilla; dorsum bare except for row of hairs on posterior part of each lateral margin. Trunk much narrower than head, tapering posteriorly to rather narrow obtuse apex, densely clothed with long hairs.

1st antenna essentially like that of female, but apparently 1-merous since suture could not be discerned. 2nd antenna absent. 1st maxilla with 2 processes. 2nd maxilla with serrulate ridge on proximal segment; lobe at base of claw with serrulate margin; terminal claw undivided at apex. Maxilliped reaching back nearly to posterior end of trunk, like that of female. Trunk legs apparently absent. Caudal ramus like that of female.

COPEPODID.—Length 0.17 mm. Prosome oval, nearly $3\frac{1}{2}$ times as long as urosome. Front with U-shaped list with arms extending over bases of 1st antennae. Pouch pointed, reaching base of second trunk legs. 1st urosomite with V-shaped ridge on ventral surface, arms of V leading to bases of ventral pair of setae. Ventral setae only slightly shorter than dorsal setae. 2nd urosomite about as long as 1st and as broad as posterior part of 1st. 3rd urosomite fused ventrally but not dorsally with caudal rami. Caudal rami with 1 pair of robust medial setae, nonplumose and more than twice as long as urosome, and 3 pairs of shorter lateral setae.

1st antenna 3-merous; 1st segment with 2 setae; 2nd segment short, unarmed; 3rd segment with the usual pair of long apical setae and 6

additional setae; esthete more than 3 times as long as appendage. 2nd antenna 3-merous; 3rd segment with long terminal seta and shorter setae near proximal end. 1st maxilla like that of female, with 2 processes. 2nd maxilla 3-merous; 1st segment with 3 rows of fine serrations; 2nd segment with a few serrations distally; 3rd segment with denticulate inner margin, apex like that of female. Maxilliped 4-merous; 1st segment longer than combined remaining segments, with longitudinal row of serrations.

Swimming legs 2 pairs, identical. Exopod with 3 outer spines, 2 terminal setae, and 2 inner setae. Endopod lateral margin with a row of spiniform teeth and a subterminal spine; medial margin with 6 plumose setae.

TYPES.—Holotype female, length .33 mm, from marsupium of adult female *Parasterope pollex*, length 1.55 mm, station 1907, Hadley Harbor, Woods Hole, Mass., USNM 119122. The other specimens listed on pages 3–4 are paratypes.

ETYMOLOGY.—The specific name “*monothrix*,” from the Greek “mono”=one and “thrix”=hair, refers to the single apical seta of the trunk legs and caudal rami.

RELATIONSHIPS.—We have placed the new species in the genus *Sphaeronellopsis* in spite of its lacking the following characters that Hansen (1905) considered to be among the most distinctive for the genus (Hansen had only females): caudal rami fused, genital area with broad anterior protuberance, seminal receptacles long and strongly curved. Because of the absence of these characters, a reasonable case could be made for assigning *S. monothrix* to *Sphaeronella* rather than to *Sphaeronellopsis*; however, the new species does agree with *Sphaeronellopsis littoralis*, until now the only species of the genus, in having a 2-merous 1st antenna, no 2nd antenna, a 3-merous maxilliped with a short terminal segment, and single terminal setae on the trunk legs and caudal rami. The factor that induced us to place our species in *Sphaeronellopsis* rather than in *Sphaeronella* is that both *S. littoralis* and *S. monothrix* are parasites of ostracods. Even if *S. monothrix* were placed in *Sphaeronella* now, it would probably be transferred to *Sphaeronellopsis* later, since the species of *Sphaeronella* are quite diverse, and eventually it will probably be necessary to subdivide the genus. Hansen (1898) may have anticipated such a subdivision, for he divided the species of *Sphaeronella* according to their morphology into 2 main groups, one made up of parasites of amphipods, the other consisting of parasites of cumaceans.

We have recently described (Bowman and Kornicker, in press) a choniostomatid from the ostracod *Pseudophilomedes ferulana* Kornicker. Only copepodids were found, and their characters agree with

those given by Hansen (1897) for *Sphaeronella*. The copepodid of *Sphaeronellopsis* being unknown, we assigned the *Pseudophilomedes* parasite provisionally to *Sphaeronella*. When adults are discovered, it may become necessary to reassign it to the genus *Sphaeronellopsis*. It differs from the copepodid of *S. monothrix* most noticeably in the structure of the 2nd maxilla and maxilliped, especially in the lack of serrations on the 1st segment of the latter.

Because *S. monothrix* in some respects is intermediate between *Sphaeronellopsis* and *Sphaeronella*, it is useful to compare it with species of the latter genus. The female of *S. monothrix* is distinguished from those of species of *Sphaeronella* by the single seta on the trunk legs and caudal rami, the 2-merous 1st antenna, the absence of the 2nd antenna, and the distinctive structure of the 2nd maxilla and maxilliped. The number of seta on the trunk legs (which may be absent) varies from 0 (in *S. acanthozonis*) to 3 (in *S. frontalis*), with 2 being most common. Only in *S. capensis* and *S. gitanopsidis* do the legs have a single seta. The caudal rami of *Sphaeronella* may be absent or be armed with 0 (*S. acanthozonis*) to 5 (*S. leukarti*, of Green, 1958) setae, mostly frequently 2. A single seta is present in *S. gitanopsidis*, *S. holboelli*, and *S. acanthozonis*.

The 1st antenna is usually 3-merous in *Sphaeronella*; only *S. decorata* resembles *S. monothrix* in having a 2-merous 1st antenna with a long 1st segment. The 2nd antenna is absent in about 5 species, but present in most species of *Sphaeronella*. The maxillipeds are usually 4-merous, but are 3-merous in a few species.

The shape of the male body, with the nearly round head and narrow trunk is quite distinctive. Among the other characters that separate the male *S. monothrix* from species of *Sphaeronella* are the absence of hairs from the head except on the posterior parts of the lateral margins, and the absence of trunk legs.

***Parasterope* Poulsen, 1965**

***Parasterope pollex* Kornicker, new species**

FIGURES 4-7; PLATE 1a,b

Cylindroleberis mariae.—Cushman, 1906, p. 366, pl. 29 (figs. 19-25) [not Baird, 1850].

TYPES.—Holotype, gravid female, USNM 114048, from station 2906, Hadley Harbor, Mass., in alcohol. Allotype, adult male, USNM 114049, dissected on slides. Paratypes, 16 adult males, 62 females, 11 juveniles, USNM 114050-114059.

ETYMOLOGY.—The specific name "pollex," from the Latin noun meaning "thumb," refers to the thumblike dorsal process on the dorsum.

RELATIONSHIPS.—In Poulsen's (1965, p. 316) key to the Astero-pinae (=Cylindroleberinae), *P. pollex* falls between *Diasterope* and *Parasterope*. The female sensory bristle of the adult female 1st antenna has 6 long terminal filaments as in *Parasterope*, whereas the tip of the ventral branch of the mandibular coxale endite has several marginal spines, which makes it resemble more closely the coxale endite of *Diasterope* than of *Parasterope*. In order to include the species in *Parasterope*, it is necessary to expand the diagnosis given by Poulsen (1965, p. 362) to include species having several small spines near the tip of the ventral branch of the coxale endite.

Specimens interpreted as being male N-1 instars of *P. pollex* have a short proximal filament on the sensory branch of the 1st antenna. This character places the species close to the genus *Diasterope* and indicates the importance of having adult females available when classifying members of this subfamily.

Cypridina mariae Baird, 1850, was designated by Sylvester-Bradley (1961, p. 402) as the type-species of *Cylindroleberis*, which is the type-genus of the family Cylindroleberidae. The structure of the appendages of the unique holotype of *Cypridina mariae* from the Isle of Skye is unknown. Although the species has been identified from many areas by others, the identifications include several species and genera (see discussion by Skogsberg, 1920, pp. 518-522). Therefore, it is not possible to determine with certainty the genus in which the type-species belongs. Because of the relative instability of generic names in the family, especially in the subfamily Cylindroleberinae, the assignment of *P. pollex* to the genus *Parasterope* must be provisional.

DESCRIPTION OF ADULT (figs. 4-6, 7a-d; pl. 1a, b).—Female shell (figs. 4a, b, d-f; pl. 1a, b): In lateral view oval, elongate, with greatest height slightly behind middle; in dorsal view with greatest width about midway between middle and posterior end; anterior and posterior margins evenly rounded; lateral surface smooth, with scattered normal pore canals, some with short hairs; incisur deep, narrow, with upper margin overlapping lower proximally; inner lamella with 40 to 42 medial bristles above incisur, 21 to 35 bristles below incisur, and about 10 bristles along ventral inner margin; medial ridge anterior to posterior margin with broad blunt spines interspersed with minute spines; about 27 spines in row between medial ridge and posterior margin; radial pore canals numerous, false radial pore canals sparse, containing hairs along posterior margin of shell; selvage narrow with fringe of hairs along anterodorsal margin; adductor muscle scars obscure, consisting of ovoid scars in cluster near middle of valves.

Male shell (figs. 4c, 6f, g): In lateral view suboval, with dorsal margin sloping posteriorly, gradually at first, and then more sharply, forming a posterodorsal angle; greatest height anterior to middle; in dorsal view greatest width anterior to middle; lateral surface smooth, with hairs in row across posterior region and sparsely distributed along ventral and posterior margins; incisur wider than in female, with rostrum projecting farther forward; inner lamella with about 42 medial bristles above incisur, 12 to 17 below incisur, and about 9 bristles along ventral margin; radial pore canals, and distribution of medial bristles on and posterior to medial ridge similar to female.

The numbers of medial bristles on the inner lamella above and below the incisur vary considerably within the species and on left and right valves of the same specimen. The numbers of bristles given in the description are for specimens on which they were counted, 2 females and 1 male. The average length of 51 adult females is 1.56 mm, average height 0.82 mm; the height calculated as percent of length is 53 percent. The average length of 8 adult males is 1.57 mm, average height is 0.86 mm; the height calculated as percent of length is 55 percent. Dimensions of shells of adult males and females are as follows:

FEMALES

USNM	station	length mm	height mm	height as % of length	remarks
114050	2906	1.46	0.79	54	parasitized
"	"	1.48	0.79	53	"
"	"	1.48	0.80	54	eggs in ovaries
"	"	1.59	0.82	52	ostracod eggs in brood chamber
"	"	1.58	0.84	53	" " " " "
"	"	1.43	0.76	53	" " " " "
"	"	1.62	0.87	54	" " " " "
"	"	1.51	0.81	54	parasitized
"	"	1.59	0.85	53	ostracod eggs in brood chamber
"	"	1.54	0.81	53	" " " " "
"	"	1.65	0.86	52	" " " " "
"	"	1.62	0.84	52	parasitized
"	"	1.41	0.75	53	"
"	"	1.47	0.77	52	"
"	"	1.46	0.76	52	"
"	"	1.51	0.80	53	"
"	"	1.56	0.86	55	eggs in ovaries
"	"	1.53	0.81	53	no eggs or parasites
"	"	1.60	0.86	54	" " " "
"	"	1.55	0.79	51	" " " "
"	"	1.55	0.84	54	ostracod eggs in brood chamber
"	"	1.56	0.82	53	" " " " "
"	"	1.58	0.84	53	" " " " "
"	"	1.62	0.83	51	" " " " "
"	"	1.61	0.89	55	" " " " "

FEMALES—continued

USNM	station	length mm	height mm	height as % of length	remarks
114050	2906	1.54	0.77	50	ostracod eggs in brood chamber
"	"	1.49	0.78	52	parasitized
"	"	1.64	0.87	53	ostracod eggs in brood chamber
"	"	1.59	—	—	" " " " "
"	"	1.49	—	—	parasitized
114048	"	1.61	0.89	55	ostracod eggs in brood chamber
114051	P. 1907	1.55	0.83	53	parasitized
"	"	1.66	0.87	52	"
"	"	1.51	0.78	52	"
"	"	1.58	0.84	53	"
"	"	1.52	0.82	54	"
"	"	1.62	0.87	55	"
"	"	1.60	0.87	54	ostracod eggs in brood chamber
"	"	1.46	0.78	53	parasitized
"	"	1.64	0.86	52	"
"	"	1.56	0.85	54	"
"	"	1.58	0.85	54	"
"	"	1.63	0.86	53	ostracod eggs in brood chamber
"	"	1.48	0.79	53	no eggs or parasites
"	"	1.56	0.81	52	1 ostracod egg in brood chamber
"	"	1.57	0.87	55	parasitized
"	"	1.58	0.84	53	"
114052	2207	1.56	0.83	53	no eggs or parasites
114053	276	1.54	0.79	51	eggs in ovaries
114054	1	1.62	0.84	52	" " "
"	1	1.48	0.79	53	ostracod eggs in brood pouch
114055	Great Harbor	1.64	0.83	51	" " " " "
114056	6	1.65	0.84	51	eggs in ovaries
134057	7	1.68	0.87	52	13 ostracod eggs in brood chamber

MALES

114049	2906	1.60	0.88	55	
114052	2207	1.58	0.85	54	
114051	1907	1.50	0.81	54	parasitized
"	"	1.54	0.84	55	
114050	2906	1.63	0.93	57	
"	2906	1.58	0.88	56	parasitized
114052	2207	1.62	0.87	54	
314056	6	1.54	0.84	54	

Female 1st antenna (figs. 4*g*, *h*): 1st joint with clusters of spines on medial surface; 2nd joint with 1 spinous dorsal bristle and clusters of spines on medial and lateral surfaces; 3rd and 4th joints fused; 3rd joint with 5 (rarely 4) spinous dorsal bristles, 1 short bare ventral bristle; 4th joint with 1 spinous dorsal and 2 bare ventral bristles; 5th joint with ventral sensory bristle with 6 terminal filaments, of these the 2 distal filaments are fused in the proximal half; 6th joint with long medial bristle with short marginal spines; 7th joint with

a-, b-, and c-bristles: a-bristle clawlike, b-bristle with 2 proximal and 2 distal filaments, c-bristle longer than b-bristle and with 5 filaments: 8th joint with e-, f-, and g-bristles: e-bristle bare, f-bristle with 3 spinous filaments near middle, and, distally, 2 filaments and spines, g-bristle with 4 to 5 filaments.

Male 1st antenna (fig. 6*h*): 1st joint with clusters of spines on medial surface; 2nd joint with 1 spinous dorsal bristle and clusters of spines on medial surface; 3rd joint with 6 spinous dorsal bristles and 1 short bare ventral bristle; 3rd separated from 4th joint by distinct suture; 4th joint with 1 spinous dorsal bristle and 2 bare slender ventral bristles; 5th joint with stout sensory bristle with numerous filaments; 6th joint with spinous medial bristle; 7th joint with a-, b-, and c-bristles: a-bristle clawlike, b-bristle with about 4 filaments, c-bristle extremely long and with about 24 filaments; 8th joint with e-, f-, and g-bristles: e-bristle bare, shorter than b-bristle; f-bristle extremely long and with 20 filaments; g-bristle with 8 filaments, longer than b-bristle.

Female 2nd antenna (figs. 4*i-k*): Protopodite with few hairs along dorsal margin and without bristle at base of endopodite. Endopodite weakly 3-jointed with bare terminal bristle. Exopodite 9-jointed: 1st elongate without bristle; 2nd to 9th joints short broad and decreasing in width distally; each of 2nd to 8th joints with short hairs in row along distolateral margin; 3rd to 8th joints each with small posterior and large anterior spine along distal margin; 9th joint with single lateral spine; bristle of 2nd joint reaching past 9th joint and with short marginal spines; bristles on 3rd to 8th joints with natatory hairs and denticulate along outer margins; 9th joint with 3 bristles: 1 short with spines, 1 long, and 1 medium with natatory hairs; long bristle denticulate along outer margin; short bristle with short marginal spines and occupying posterior position.

Male 2nd antenna (figs. 6*i-l*): Protopodite bare, larger than on female. Endopodite 3-jointed: 1st joint bare; 2nd joint with 3 bare bristles, 1 short, 2 medium; 3rd joint with finely annulated bristle proximally, and, distally, small tubercles in rows and 6 to 7 serrated terminal ridges. Exopodite larger than on female and without lateral spines on joints; 2nd joint more elongate than on female; each of 1st to 8th joints with clusters of short hairs distolaterally; bristles on 2nd to 9th joints with natatory hairs but without marginal denticulations; 9th joint with 4 bristles, 1 short, 1 medium, and 2 long.

Female mandible (figs. 5*a-i*): Exopodite 60 percent length of 1st endopodite joint, with 2 short distoventral bristles and hirsute terminal process. Endopodite: 1st joint with 3 long ventral bristles, 1 with short, and 2 with long spines; dorsal margin of 2nd joint with 4 long stout spinous a-, b-, c-, d-bristles and 5 additional bristles (proximal

bristle short, slender with few spines distally; between b- and c-bristles, 1 short and 1 medium spinous bristle; between c- and d-bristles, 1 long stout spinous bristle; following d-bristle, 1 medium slender spinous bristle); ventral margin of 2nd joint with 1 medium and 2 long spinous bristles; medial side near base of c-bristle with 4 to 5 unequal spinous bristles in row; end joint with 1 bare stout claw and 1 short and 4 long bristles. Basale endite with 4 (rarely 3) pectinate terminal bristles, 1 short bare bristle and 4 (rarely 3) triaenid bristles with 4 pairs of spines; glandular peg well developed; dorsal margin of basale with 2 slender terminal bristles with short spines. Coxale: ventral branch with long and short spines in roughly 4 transverse rows and several small spines or hairs near tip; dorsal branch: ventral margin with 6 rounded teeth and distally a crest of spines; terminal margin with short spines in row and slender terminal spine; dorsal margin with long slender hirsute spine near terminal end. (Distal part of dorsal branch of coxale missing on most specimens examined.)

The right mandible on a female examined is aberrant, having on the 2nd joint of the endopodite only 2 bristles on the dorsal margin, 2 on the ventral margin, and 2 on the medial surface (fig. 5*b*), and also in having 2 of the 3 ventral bristles on the 1st endopodite joint fused along their proximal $\frac{2}{3}$; the 3rd bristle is bifurcate at the tip; the 2nd endopodite joint is almost $\frac{1}{2}$ the length of the same joint on the normal left mandible; the end joint is larger than the end joint of the normal mandible and does not have a small medial bristle.

Male mandible (fig. 6*m*): 2nd joint of endopodite differs from female in having on dorsal margin 1 additional bristle proximal to a-bristle, and, on some specimens an additional short bristle between b- and c-bristles, and in greater spinosity of medial surface. Basale endite differs in having 4 to 7 pairs of spines on triaenid bristles compared to 4 on female.

Maxilla (figs. 5*j*, 7*a*): No sexual dimorphism. Epipodite pointed and hirsute. Proximal endite with 1 short and 3 long bristles; distal endite with 3 long bristles. Dorsal margin of basale hirsute, with 2 short bare bristles; ventral margin with short bare bristle near middle and long spinous distal bristle. Endopodite: 1st joint with 1 short bare anterior bristle and 1 medium terminal bristle; end joint with 1 long spinous bristle. Proximal spear-shaped bristle of baleen comb longer than adjacent oar-formed bristles.

5th limb (figs. 5*k*, 7*l*): No sexual dimorphism. Form of appendage typical for genus. Epipodial appendage with 59 to 60 marginal

bristles. Anterodorsal margin of comb with about 6 long hairs. Proximal end of comb with sclerotized dorsally oriented process.

6th limb (fig. 5*m*): No sexual dimorphism. Anterior margin concave, with 2 slender bristles; medial side with small proximal spine near anterior margin; anterior corner with 2 plumose bristles, followed by 12 to 17 (rarely 10) spinous posteroventral bristles; anterior part of ventral margin, posterior margin, and medial surface hirsute; lateral anterior flap with fringe of hairs anteriorly.

The number of bristles along the ventral and posterior margins of the 6th limbs and shell lengths of selected specimens are as follows:

<i>sex</i>	<i>station</i>	<i>number of bristles</i>		<i>carapace length</i>
		<i>left limb</i>	<i>right limb</i>	
♀	2906	14	15	1.61
♀	2906	15	15	1.59
♀	2906	13	13	1.41
♀	1907	17	17	1.55
♀	1907	15	16	1.66
♂	2906	12	14	1.60
♂	1907	16	16	1.54
♂	1907	15	15	1.50
♀	6	17	16	1.65
♀	7	12	10	1.68
♀	1	15	16	1.62

7th limb (figs. 5*n-p*): 6 cleaning bristles in proximal group, 6 in distal group; each bristle with 2 to 4 distal bells; tips of cleaning bristles spinous. Terminal comb with 12 to 13 pinnate teeth on each side. Male and female similar.

Furca (figs 6*a, b*): Each lamella with 6 curved claws with pointed tips, followed by 2 to 3 spinous bristles; convex and concave margins of claws with large and small spines in row distally; spinous bristles decreasing in length proximally on lamella. Furca similar in male and female.

Rod-shaped organ (figs. 5*g, 7b*): Elongate, similar in male and female.

Medial eye (figs. 5*g, 7b*): Eye well developed and with clusters of hairs dorsally. Similar in male and female.

Lateral eyes: Each eye of female (fig. 6*e*) about $\frac{1}{2}$ diameter of medial eye and with about 6 undivided ommatidia. Male eye (fig. 7*d*) similar in size to medial eye and considerably larger than lateral eye of female; about 16 divided ommatidia present.

Lips (fig. 6*e*): No sexual dimorphism. Upper lip: Central lobe with a hirsute lateral lobe on each side; each lobe with anterior

spine, spine on central lobe smaller than spines on lateral lobes; narrow canal extending into spines on lateral lobes.

Lower lip: Hirsute, rounded, consisting of 2 lobes, each smaller than lateral lobe of upper lip.

Copulatory organs: Female genital organs ill defined. Male copulatory limbs well developed, each having 2 elongate lobes with 1 to 2 bristles (fig. 7c).

Dorsum (fig. 6d): Margin ventral to dorsal process with fine hairs; dorsal process finger-like, hirsute. Male and female similar.

Description of N-1 male instar (figs. 7e-m). Shell (figs. 7e, f) in lateral outline similar to adult female. 1st antenna (fig. 7g) similar to that of adult female with following exceptions: 3rd joint with 6 dorsal bristles; sensory bristle on 5th joint with short filament proximal to 6 terminal filaments. 2nd antenna: Exopodite similar to that of female; endopodite 3-jointed with 3rd joint weakly separated from 2nd: 1st joint bare; 2nd joint with 2 short bristles; 3rd joint with proximal bristle. Mandible (figs. 7i, k) 5th, 6th, and 7th limbs, upper and lower lips, rod-shaped organ and medial eye (fig. 7l), furca and dorsal process similar to adult female. Lateral eyes (fig. 7m) similar to those of adult male except with smaller ommatidia. Dimensions of carapaces of N-1 male instars are as follows:

USNM	station	length mm	height mm	height as % of length	remarks
114050	2906	1.42	0.80	57	
114058	Coll. 2	1.43	0.73	51	
114053	276	1.38	0.72	52	
114052	2207	1.38	0.75	54	
114059	Coll. 4	1.43	0.77	54	parasitized

Several juvenile males differed from N-1 males described above in being larger and in having numerous filaments on the sensory bristle on the 5th joint of the 1st antenna. These specimens appear to have continued to molt after reaching the N-1 stage described above without acquiring all characters of the adult male. Dimensions of 3 specimens are as follows:

USNM	station	length mm	height mm	height as % of length
114050	2906	1.72	0.96	56
	2906	1.56	0.84	54
114054	1	1.70	0.93	55

It is suggested that the occurrence of unusually large specimens of an ostracod species occasionally reported in the literature and generally attributed to postadult molting may be caused instead by delay of sexual maturity.

Measurements of shells of some of the smaller juveniles in the collection are as follows:

USNM	station	length mm	height mm	height as % of length	sex
114060	260	1.02	0.57	56	not determined
114053	276	0.98	0.53	54	"
"	276	0.99	0.50	51	"
"	"	0.84	0.46	55	"
"	"	0.86	0.48	56	"
"	"	1.01	0.57	56	"
"	"	0.83	0.44	53	"
114050	2906	1.15	0.67	58	♀
"	"	1.08	0.61	56	♀
"	"	1.14	0.61	54	♀
"	"	1.17	0.64	55	♀ ?
"	"	1.27	0.74	58	♂ ^a

^aSeven filaments on sensory bristle of 1st antenna.

COMPARISONS.—With the exception of *Parasterope corrugata* Poulsen, 1965, the 8 species of *Parasterope* listed by Poulsen (1965, table 17, pp. 310–311) do not have the thumblike dorsal process that is present on the dorsum of *P. pollex*. *Parasterope pollex* differs from *P. corrugata* in having 12 to 17 bristles along the posteroventral margin of the 6th limb compared to about 3 on *P. corrugata*, and in having 2 ventrodistal bristles on the 4th joint of the 1st antenna compared to no bristles on *P. corrugata*. *Parasterope pollex* differs from *Cylindroleberis psitticina* Darby, 1965, in having only 2 bristles on the anterior corner of the 6th appendage compared to 6 on *C. psitticina*, and in having no laterodistal bristle on the 1st joint of the 1st antenna. The adult female of *C. psitticina* has 6 dorsal bristles on the 3rd joint of the 1st antenna compared to only 5 on *P. pollex*.

The appendages of *Cypridina mariae* Baird, 1850, are unknown. The unique dried holotype (no. 1945, 9.26, 96–100) is in the Baird Collection at the British Museum (Natural History). Miss Patricia D. Lofthouse of the Entomostraca Section of the British Museum on request kindly measured the length of the specimen and found it to be 2.33 mm, considerably longer than adults of *P. pollex*. The length of the adult female identified as *Asterope mariae* (Baird) by Brady and Norman (1896, p. 630) is 2.4 mm. Brady and Norman (1896, pl. LI: fig. 7) illustrate the 6th limb as having 4 anteroventral and 25 posteroventral bristles, many more than are present on *P. pollex*.

Appendages of specimens from San Diego Bay, Calif., identified as *Cylindroleberis oblonga* (Grube, 1859) by Sharpe (1908, p. 423, pl.

LXII: figs. 1-4) are incompletely known, but lateral outline of the shell is more acuminate anteriorly than that of *P. pollex*. Unfortunately, specimens identified by Sharpe (USNM 13108) are missing from the museum collection, so that appendages could not be examined. Specimens from off the California coast identified as *Cylindroleberis mariae* (Baird) by Juday (1907, p. 143) are described incompletely, but, according to the description of the furca (Juday, 1907, p. 144), each lamella bears 10 claws; it thus differs from the furca of *P. pollex*, which has only 8 to 9 claws on each lamella.

Cyridina oblonga Grube (1859, p. 335) has only 11 bristles on the 7th limb and no bristles on the anterior corner of the 6th limb (Grube, 1859, pl. XII: fig. E). Specimens identified as *Cylindroleberis oblonga* (Grube) by Müller (1894, p. 219) differ from *P. pollex* in having 25 posteroventral and 4 anteroventral bristles on the 6th limb (Müller, 1894, pl. 5: fig. 33). Specimens identified as *Asterope oblonga* (Grube) by Sars (1887, p. 203) have a 6th limb with 24 posteroventral and 6 anteroventral bristles (Sars, 1887, pl. 5: fig. 10). Specimens identified as *Cylindroleberis mariae* (Baird) by Brady (1868, p. 465) have 6 anteroventral bristles on the 6th limb (Brady, 1868, pl. 41: fig. 1f); the 3rd joint of the 1st antenna of the adult female of Brady's specimens has 6 dorsal bristles (pl. 41: fig. 1c) compared to 5 on *P. pollex*.

Specimens identified by Sars (1887, p. 203) as *Asterope elliptica* Philippi have about 24 posteroventral and 5 to 6 anteroventral bristles on the 6th limb (Sars, 1887, pl. IV: fig. 1). *Asteropina extrachelata* Kornicker (1959, p. 241) has on the 6th limb 24 posteroventral and 4 anteroventral bristles. *Asteropina setisparsa* Kornicker (1959, p. 239) has only 1 posteroventral bristle and 3 anteroventral bristles on the 6th limb. The carapaces of the adult male and female of *Asterope judayi* Hartmann (1959, p. 201) are shorter than *P. pollex*, and the height of the female shell is 62 percent of its length, according to Poulsen (1965, p. 347), who estimated it from Hartmann's figure (Hartmann, 1959, pl. 33: fig. 32). The height of the female shell of *P. pollex* is only 51 to 55 percent of its length.

The N-1 instar of the male of *P. pollex* resembles *Diasterope tenuista* Poulsen, 1965, of which only the juvenile male is known. It differs from that species in having a thumblike posterior process and slender c- and d-bristles on the 2nd endopodite joint of the mandible.

Cushman (1906, p. 366) identified specimens collected in the "Gulf of Canso" across from Woods Hole, Mass., on Aug. 3, 1905, as *Cylindroleberis mariae* (Baird). The USNM contains in its collection a slide containing 4 dried ostracods (USMN 114061) labeled "*Cylindroleberis mariae* Baird, Aug. 3, '05, Gulf of Canso, Woods Hole, Mass., Coll. by J. A. Cushman." One of the 4 is an adult male and another an adult female with 10 ostracod eggs in its brood chamber.

The female was soaked in glycerin and its appendages examined and found to be identical to the female of *P. pollex*. Therefore, *C. mariae* (Baird) of Cushman, 1906, not of Baird, 1850, is placed in synonymy with *P. pollex*. The description of specimens from the "Gulf of Canso" published by Cushman (1906, p. 366, pl. 29: figs. 19-25) differs considerably from *P. pollex*. Two glass slides containing mounted ostracod appendages are in the Cushman Collection at the USNM. One of these is labeled "*Asterope teres* (Norman) ♂, Woods Hole, Mass., Aug. 3, '05, (USNM 114062)"; the other is labeled "*Asterope teres* (Norman) ♀, Woods Hole, Mass., Aug. 3, '05 (USNM 114063)." Because of the locality and collection date of the specimens and because Cushman (1906) did not report the presence of *A. teres* in his publication, it is probable that the slides contain the specimen upon which Cushman based his description of *C. mariae*. Both specimens are identifiable as *P. pollex*. The specimen labeled "♀" on the slide is actually a juvenile male and this accounts for some of the differences between Cushman's description of the "female" of *C. mariae* and the female of *P. pollex*, i.e., the presence of 6 dorsal bristles on the 3rd joint of the 1st antenna (Cushman, 1906, pl. 29: fig. 22) and also a total of only 7 claws and bristles on the left lamella of the furca (loc. cit., fig. 25). No explanation is available for the presence of 2 slender bristles proximal to the a-bristle on the 2nd endopodite joint of the mandible (loc. cit., fig. 24). Two bristles in this position were observed only on the adult male of *P. pollex*. They are present on the male of *C. mariae* on Cushman's slide but not on the "female." Cushman (1906, p. 367) gives the length of the male shell as 1.8 to 2 mm, considerably larger than adult males of *P. pollex*. Because of the dried condition of the available specimens, their length can not be accurately measured. An adult female soaked in glycerine measured only 1.43 mm long, 0.78 mm high. The length of the dried male in the Cushman Collection is only 1.27 mm in its shriveled condition.

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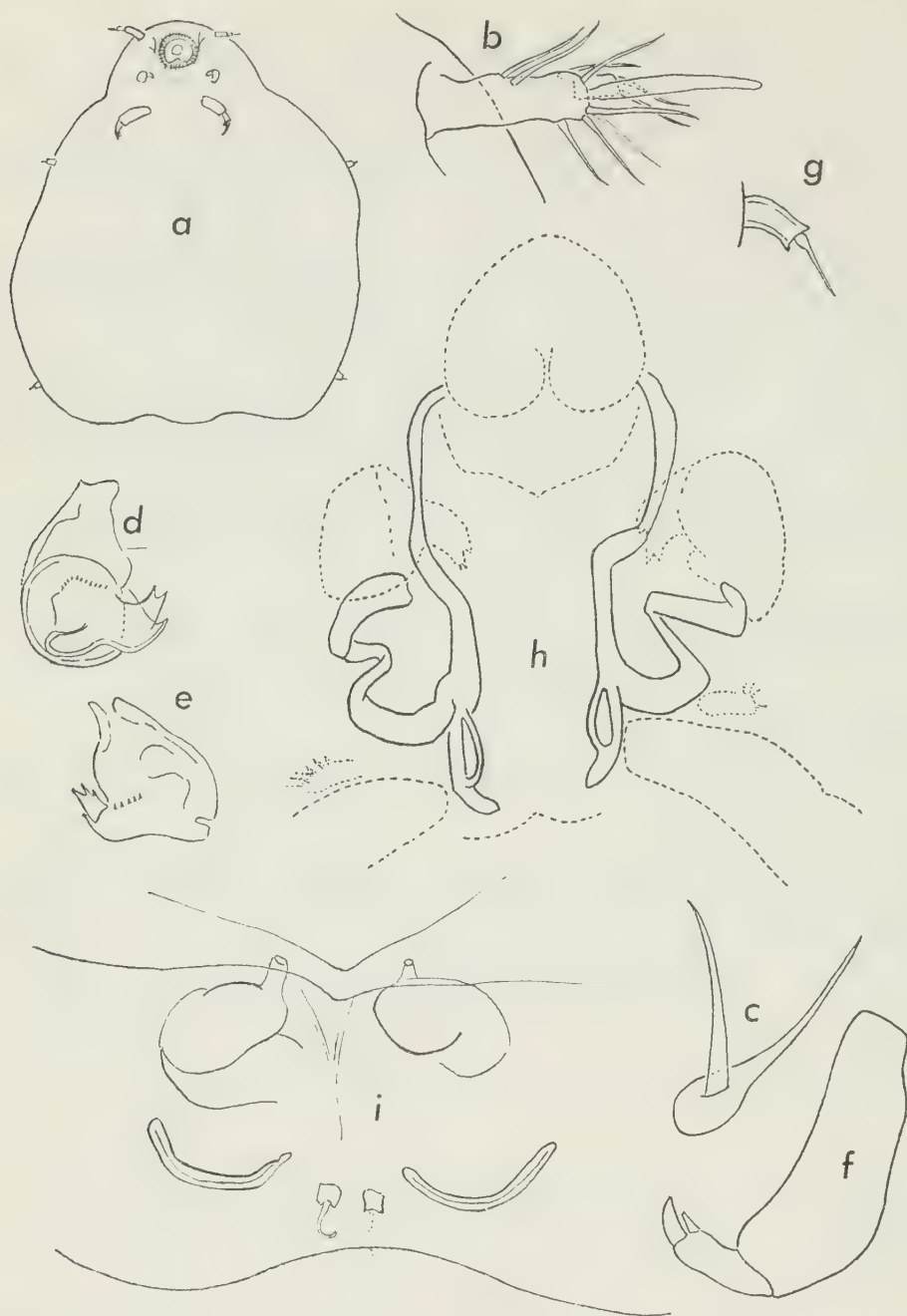


FIGURE 1.—*Sphaeronellopsis monothrix* Bowman and Kornicker, female: *a*, holotype, ventral aspect; *b*, 1st antenna; *c*, 1st maxilla; *d, e*, 2 views of 2nd maxilla; *f*, maxilliped; *g*, posterior trunk leg; *h*, submedian skeleton; *i*, genital area.

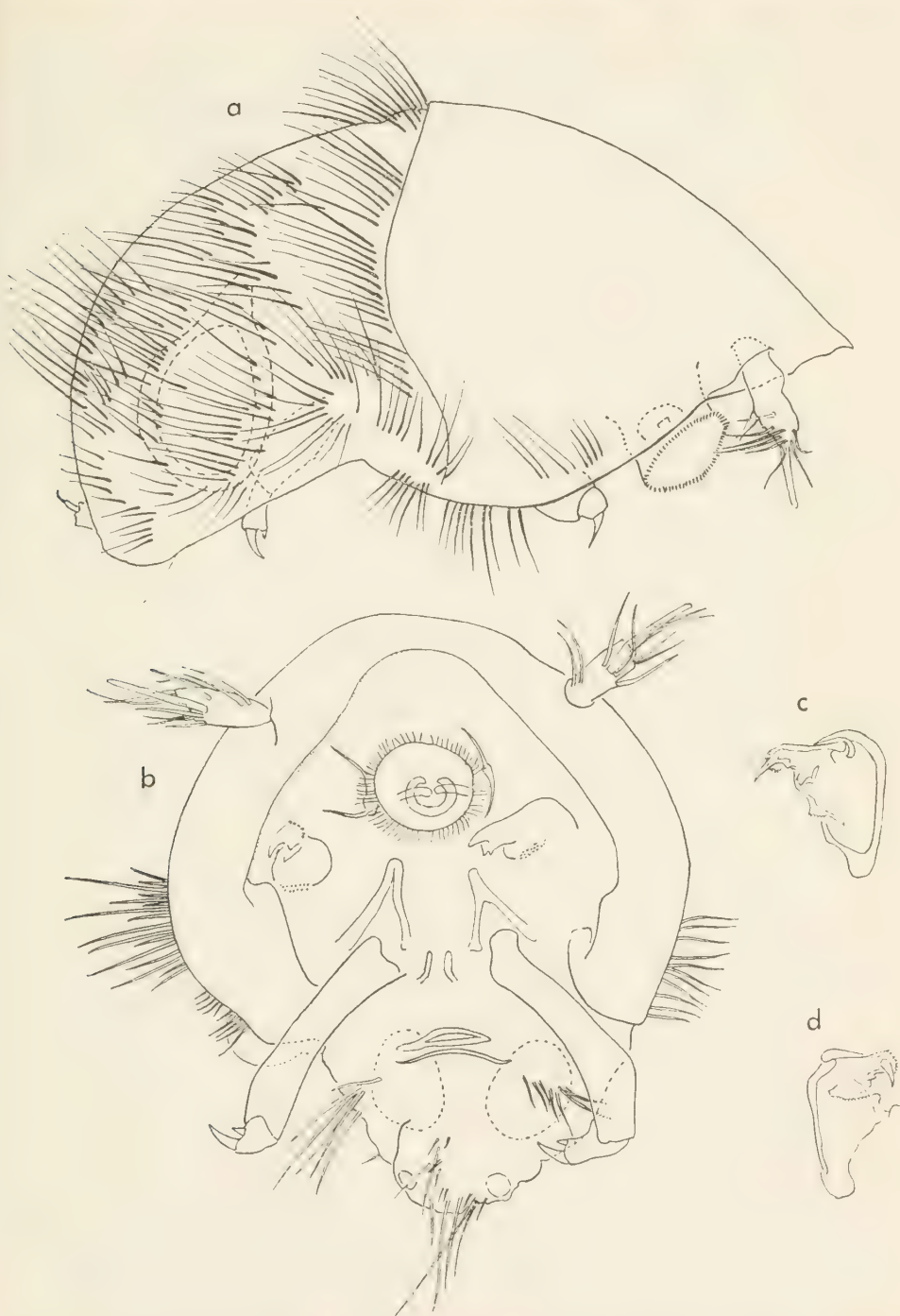


FIGURE 2.—*Sphaeronellopsis monothrix* Bowman and Kornicker, male: a, lateral aspect; b, ventral aspect; c,d, 2 views of 2nd maxilla.

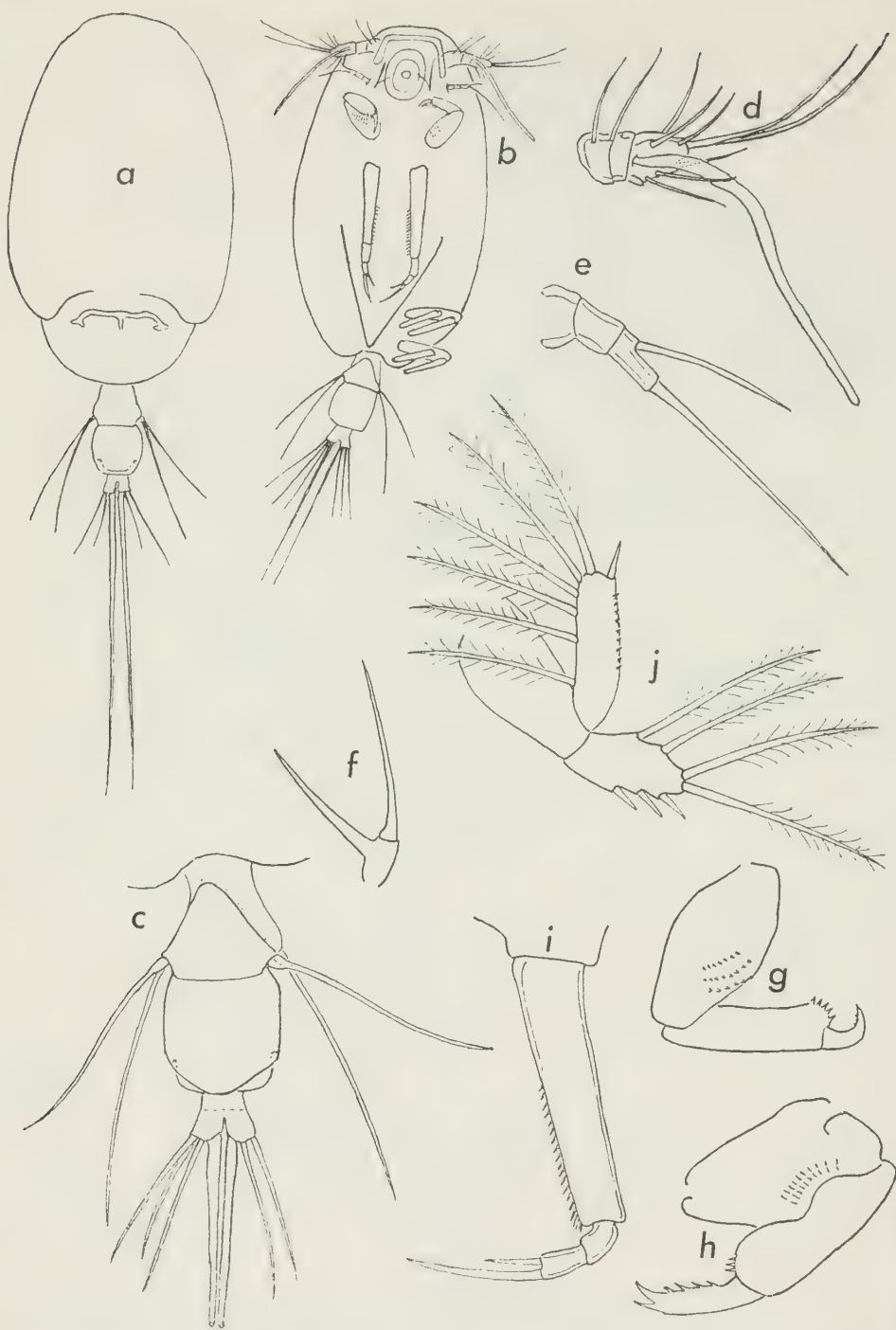


FIGURE 3.—*Sphaeronellopsis monothrix* Bowman and Kornicker, copepodid: *a*, dorsal aspect; *b*, ventral aspect; *c*, urosome, ventral; *d*, 1st antenna; *e*, 2nd antenna; *f*, 1st maxilla; *g, h*, 2 views of 2nd maxilla; *i*, maxilliped; *j*, posterior trunk leg.

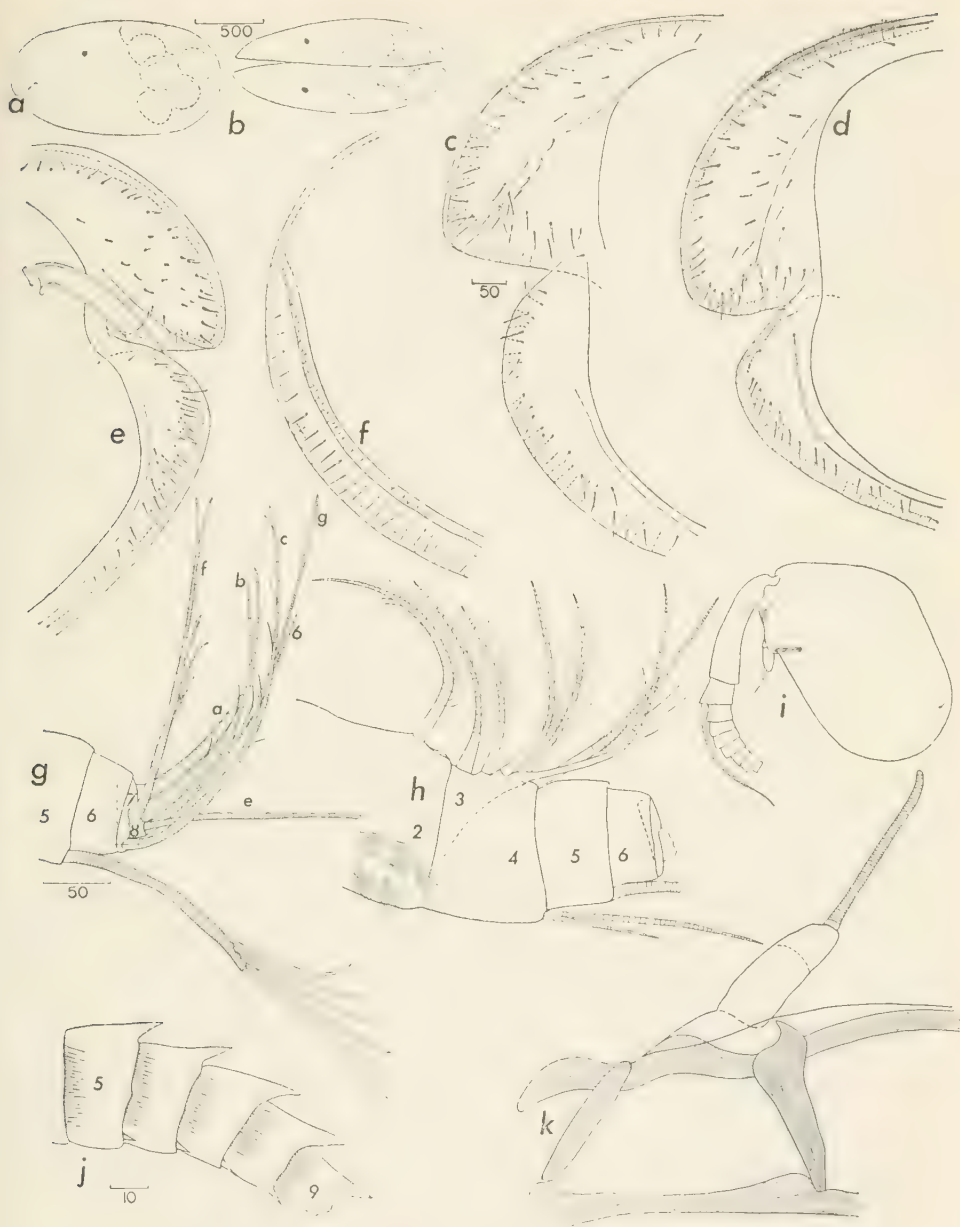


FIGURE 4.—*Parasterope pollex* Kornicker, carapace of holotype: *a*, lateral view; *b*, dorsal view; *c*, inside anterior right valve of allotype; *d*, inside anterior right valve of holotype. Female: *e*, inside anterior left valve with 2nd antenna through sinus; *f*, inside posterior left valve. 1st antenna, lateral view: *g*, joints 5-8; *h*, joints 2-8. 2nd antenna: *i*, medial view (bristles on joints 3-9 of exopodite not shown); *j*, joints 5-9 of exopodite, lateral view (bristles not shown); *k*, endopodite medial view. (Same scale in microns: *a*, *b*; *c-f*, *i*; *g*, *h*; *j*, *k*.)

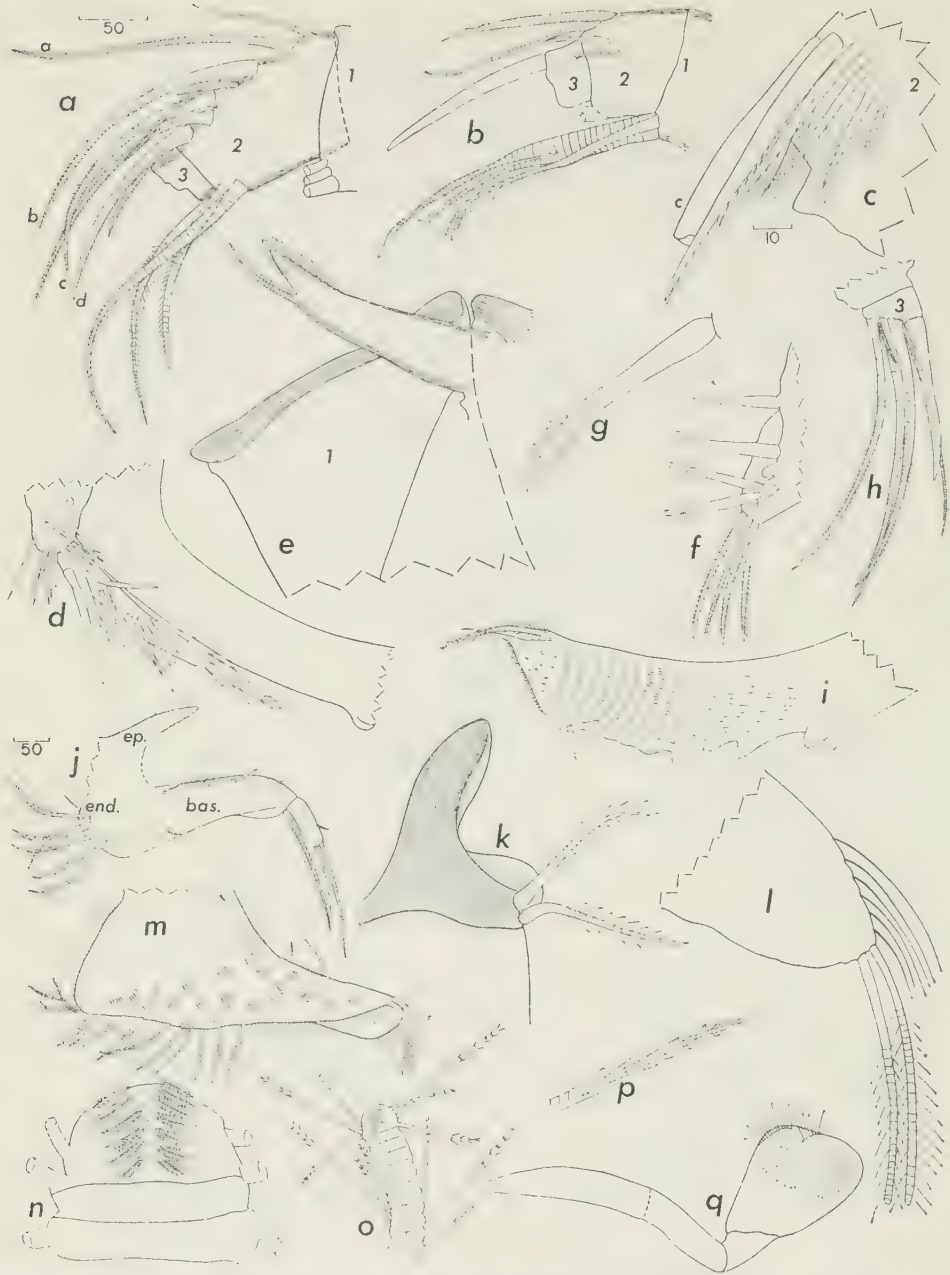


FIGURE 5.—*Parasterope pollex* Kornicker, female, mandible: *a*, bristles on joint 2 of endopodite, lateral view; *b*, joint 2 of abnormal mandible, medial view; *c*, medial bristles on 2nd joint of normal mandible; *d*, ventral branch of falciform process, medial view; *e*, exopodite, lateral view; *f*, basal endite, medial view; *g*, enlargement of triaenid bristle; *h*, end joint of endopodite, medial view; *i*, distal part dorsal branch of falciform process, medial view; *j*, maxilla (baleen-comb not shown). 5th limb: *k*, sclerotized process and bristles at proximal end of comb; *l*, distal end of comb (only 2 bristles of comb shown); *m*, 6th limb, medial view. 7th limb: *n*, terminal comb; *o*, distal part; *p*, detail of bells on bristle; *q*, rod-shaped organ and medial eye. (Same scale in microns: *a*, *b*, *f*, *h*, *q*; *c*–*e*, *g*, *i*, *k*, *l*, *n*, *p*; *j*, *m*, *o*.)

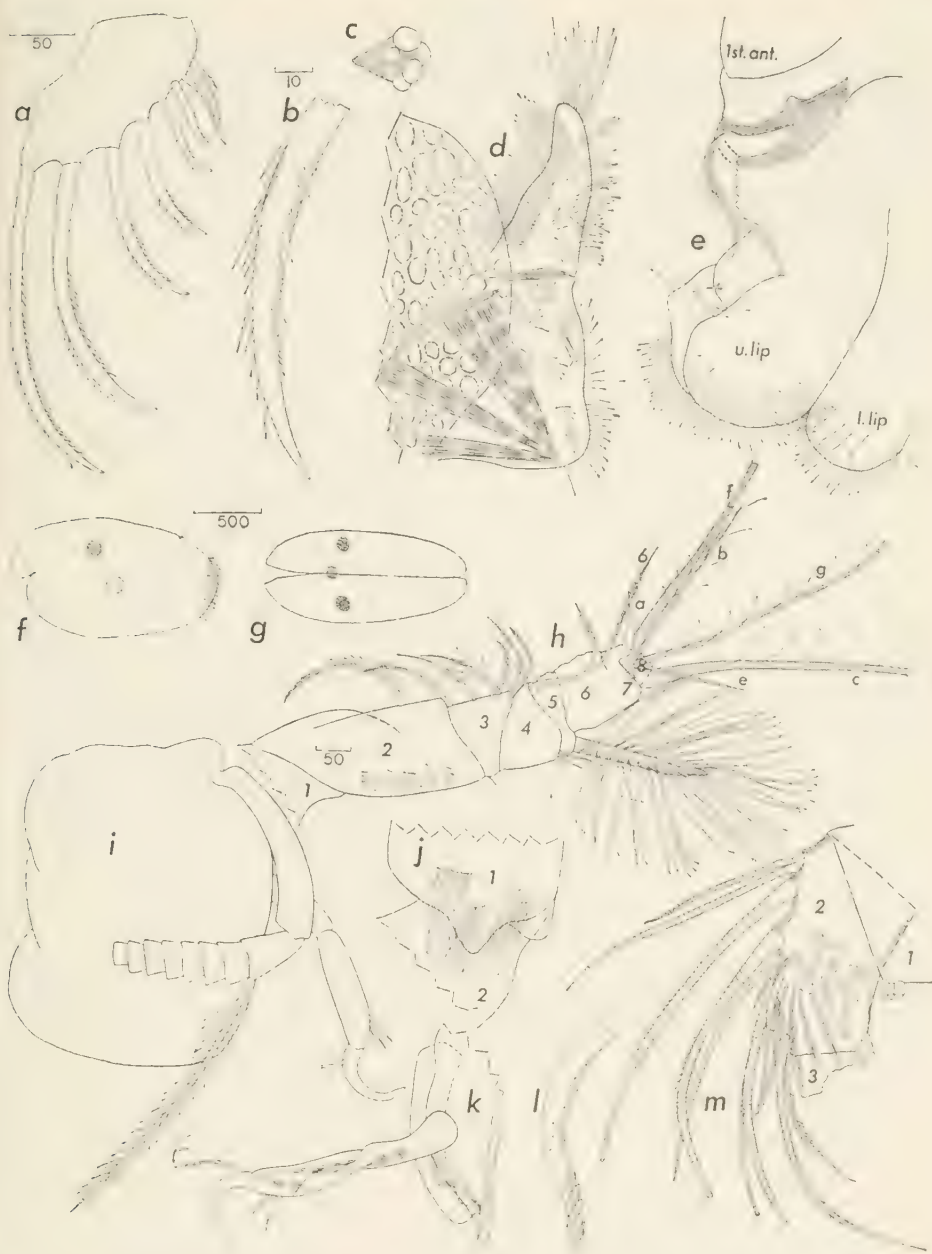


FIGURE 6.—*Parasterope pollex* Kornicker, female, furca: *a*, right lamella, medial view; *b*, enlargement of claw 1, distal part; *c*, lateral eye; *d*, dorsum with dorsal process (dotted circles=oil globules); *e*, frontal region showing lips, lateral view (compressed under cover glass). Male allotype, carapace: *f*, lateral view; *g*, dorsal view; *h*, 1st antenna, medial view. 2nd antenna: *i*, lateral view (bristles on exopodite joints 3–9 not shown; bristle broken on end joint of endopodite); *j*, hairs on distal end of 1st exopodite joint, lateral view; *k*, endopodite, medial view; *l*, enlargement of tip of 3rd joint of endopodite; *m*, mandible bristles on 2nd endopodite joint, medial view. (Same scale in microns: *a*, *c*–*e*, *m*; *b*, *j*, *l*; *h*, *i*, *k*; *f*, *g*.)

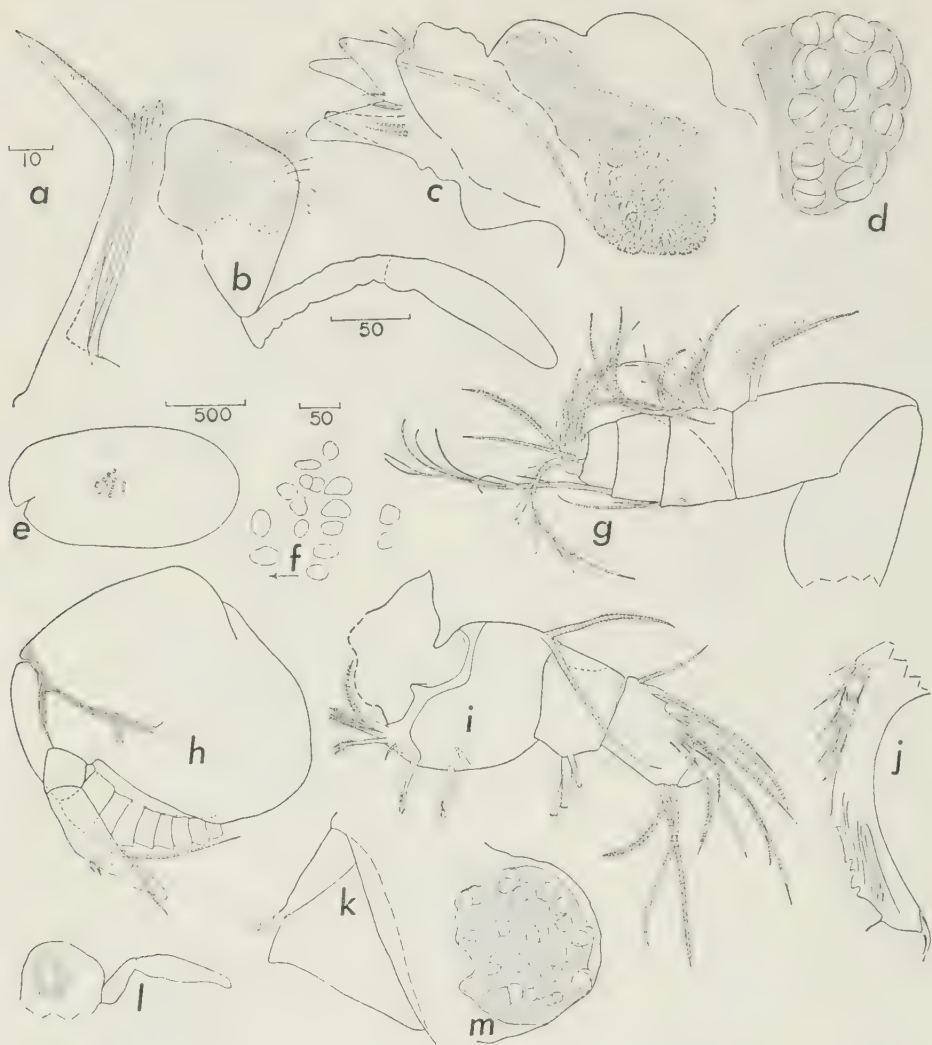
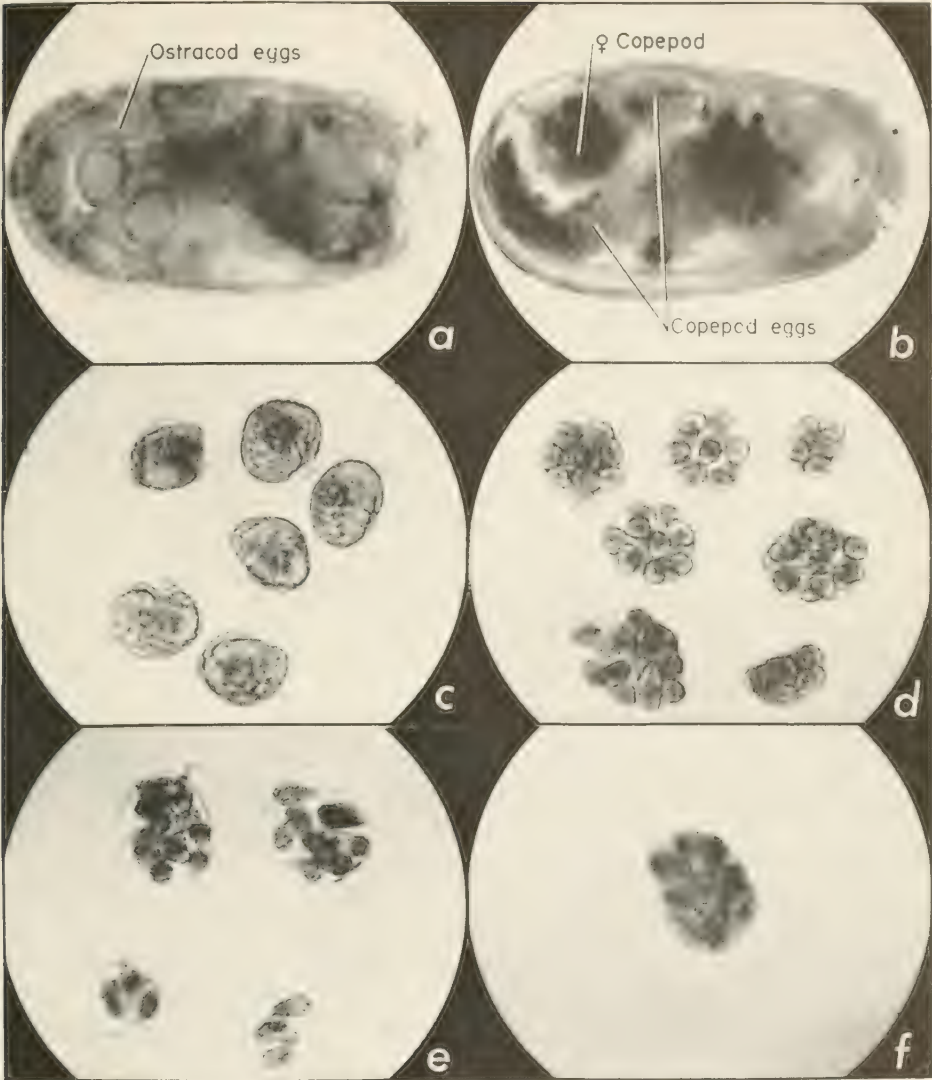


FIGURE 7.—*Parasterope pollex* Kornicker, male allotype: *a*, maxilla, spear-shaped bristle and 3 proximal bristles on baleen-comb; *b*, medial eye and rod-shaped organ; *c*, copulatory organ; *d*, lateral eye. Male N-1 instar: *e*, carapace, lateral view; *f*, enlargement of muscle scars, lateral view; *g*, 1st antenna, lateral view; *h*, 2nd antenna, medial view (basal spines and bristles of joints 3-9 not shown on exopodite); mandible: *i*, medial view (only end claw shown on 3rd endopodite joint); *j*, falciform process, medial view; *k*, exopodite lateral view; *l*, medial eye and rod-shaped organ; *m*, lateral eye. (Same scale in microns: *a*; *b-d*, *j*, *k*, *m*; *f-i*, *l*; *e*.)



Parasterope pollex Kornicker: *a*, ovigerous female, lateral; *b*, parasitized adult female, lateral; *c*, eggs. *Sphaeronellopsis monothrix*, ovisacs, showing 3 developmental stages: *d*, round eggs; *e*, pyriform eggs; *f*, copepodids. (*a*, *b*: 34×; *c*-*f*: 44 .)

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3614

Revision of the Cactus Plant Bug Genus *Hesperolabops* Kirkaldy (Hemiptera: Miridae)

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High among the successful attempts to control weeds by manipulation of their insect enemies stands the control of cacti. Huffacker (1959, p. 253) has summarized an important part of that effort: "The urgency for controlling prickly pear in Australia in the 1920's was unchallengeable, and the subsequent success of that work has stood as a landmark not likely to be equalled." But to demonstrate the complexity of the role of the cactus in man's economy, he continues:

However, *Opuntia* spp. are not always considered pests. Use of these plants in Hawaii, South Africa, Madagascar, the United States, and Mexico as human food, fodder, and a source of water for stock on dry ranges has been reported. . . . Importation of *Cactoblastis cactorum* (Berg) into the United States has long been denied largely on such grounds, although it has been stated that, in West Texas alone, an area of some 60,000,000 acres of range land are infested with *Opuntia* and consequently suffer greatly lowered values. On spineless cactus plantations in some areas of South Africa it has been necessary to control the cochineal previously introduced against the related pest cacti.

Heeding Wilson's (1964, p. 225) statement that the "biological control of weeds is intimately connected with basic ecological problems," field workers seeking to understand the basic ecological problems in regards to cacti have been finding previously unreported relationships.

Attempts to identify specimens of cactus-frequenting insects submitted by F. D. Bennett revealed the need for a taxonomic revision of the mirid genus *Hesperolabops* Kirkaldy. For this genus, Carvalho's (1956, p. 106) "Catalogue of the Miridae of the world" listed three species of which one had two named varieties. Study shows that the two varieties deserve full specific status, that one of the species must be synonymized, and that one new species must be described.

Material for this revision consisted of specimens in the United States National Museum and in three lots furnished by F. D. Bennett, Commonwealth Institute of Biological Control, West Indian Station, Curepe, Trinidad, W.I.; by C. G. Martell, Escuela Nacional de Agricultura, Chapingo, Mexico; and by J. C. Schaffner, Texas A. and M. University, College Station, Tex.

To my wife, Elsie Herbold Froeschner, I am grateful for the illustrations.

The endings of the species names have been made to conform to the statement in the "Bulletin of Zoological Nomenclature" (1964, vol. 21, p. 172, Case 18), that all "-ops" names be treated as masculine.

***Hesperolabops* Kirkaldy**

Hesperolabops Kirkaldy, 1902, p. 249.

Stylopidea Hunter, Pratt and Mitchell, 1912, p. 22.

Within its area of natural occurrence, North and Central America, members of this genus are recognized readily by the dorsolateral angles of the head being formed into long stalks that bear the eyes at their tips, as illustrated in figure 1.

The geographic range of this genus is from the southwestern United States (Texas) south to El Salvador.

Hesperolabops was described for a new species, *H. gelastops*, which is the type of the genus by virtue of being the only included species. *Stylopidea* was also described with a lone new species, *S. picta*, which is thereby the type of that genus. The Uhler credit for the name *Stylopidea* given with the original description apparently was received from Heidemann, "who examined all of the hemipterous insects taken on cactus" (Hunter et al, p. 17). His use of the name undoubtedly was based on specimens in the collection of the U.S. National Museum bearing the Uhler manuscript label with this name; however, no published Uhler treatment of that name has been found. Hunter, Pratt, and Mitchell's brief description of the color and the stalked eyes was adequate to gain for them the authorship of the genus and the species names. Knight (1928, p. 68) synonymized *Stylopidea* under *Hesperolabops*.

The frequent listing of these bugs from "*Opuntia*" suggests that they occur promiscuously on the various species of that genus; however, when the available specimens were arranged according to the present taxonomic treatment, the limited associated ecological data suggested the possibility of each species confining its attentions to one or at most a few species of cacti. At least, where specifically determined cactus hosts were found on specimen labels, one species of bug occurred on one cactus host: *H. gelastops* on *O. engelmannii*; *H. nigriceps* on *O. megacantha*; and the new species on *O. tomentosa*. The single host note for *H. periscopis* was for a cactus of another genus, *Acanthocereus horridus*. Field observations are needed to confirm or refute this theory of host specificity.

The species may be arranged in two groups by the following characters:

GROUP A

(includes *nigriceps*, *sanguineus*, *mexica*)

hemelytron wholly fuscous
frons strongly tumid (fig. 6)
male genital capsule with a long,
slender process at right posterodorsal
angle (figs. 16, 18, 26)

GROUP B

(includes *gelastops*, *periscopis*)

hemelytron not wholly fuscous
frons weakly tumid (fig. 7)
male genital segment without this
process (fig. 3)

Nymphs associated with adults of *H. gelastops* and *H. sanguineus*, and therefore tentatively identified as these species, show the greatly elongated eye stalks characteristic of the imago of the genus. In addition, the *H. sanguineus* nymphs show a much more tumid frons than do the nymphs of *H. gelastops*—even as do their respective adults.

Key to the Species of the Genus *Hesperolabops*

1. Hemelytra wholly fuscous to black (teneral specimens sometimes slightly paler along costa); male genital segment with a very long, slender process on right posterodorsal angle (figs. 16, 18, 26) 2
- Hemelytra not wholly fuscous; male genital segment without a long, slender process on right posterodorsal angle (figs. 3, 31) 4
2. Calli and/or collar blackened, at least laterally; scutellum fuscous to black except in depressed basal areas; right clasper of male without a long, slender, upcurved hook at apex (figs. 14, 20) 3
- Calli, collar and scutellum wholly red to orange red, in no part blackened; apex of right clasper of male with a long, slender, upturned hook that is almost as long as stout basal part (fig. 24); length 5.6–6.4 mm.

sanguineus Carvalho
3. Calli with outer third or more of dorsal surface strongly fuscous to black; male genital segment with a small, slender hook laterad of base of long curved process at posterodorsal angle (fig. 18); length 6.3–7.3 mm.

nigriceps Reuter
- Calli with fuscous to black coloring restricted to outer face, not invading dorsal surface; male without a hook at this point (fig. 16); length 6.2–7.0 mm.

mexica, new species

4. Hemelytron, except apical two-thirds of clavus, inner apical angles of coria and membrane, wholly red; right clasper without a rectangular angulation dorsally (fig. 30); length 6.2 mm **periscopis** Knight
 Hemelytron fuscous with costa and adjacent edge of corium and outer third or more of cuneus cream colored to white; right clasper of male with a large, rectangular angulation dorsally (fig. 4); length 5.4-7.0 mm.
gelastops Kirkaldy (fig. 1)

***Hesperolabops gelastops* Kirkaldy**

FIGURES 1-5, 7-10

Hesperolabops gelastops Kirkaldy, 1902, p. 249, pl. 5 (fig. 2).

Stylopidea picta Hunter, Mitchell, and Pratt, 1912, p. 22. [New synonymy.]

Within the genus this is the only species with white or cream costal edges on corium and cuneus of fuscous forewings. The male is recognized readily by the dorsal angulation on the right clasper (fig. 4). Another male feature worthy of note and present in no other species of the genus is a bispinose area within the genital capsule (fig. 5, stippled area).

The distinctness of two species, *H. gelastops* and *H. picta*, as recognized by Knight (1928, p. 68) and accepted by Carvalho (1955, p. 106) is not supported by modifications of the male genital segment: one structural pattern is involved. The color pattern shows some variation in intensity of the fuscous areas, being paler in the northern specimens where the calli are rosaceous in contrast to the black color of the calli of most of the southern specimens. The pale costal margin also varies in width and gives the illusion of variation in stoutness of the specimens. Pale individuals as well as intermediates, however, occur throughout the range and eliminate any need for taxonomic recognition. Thus, morphologically, *H. picta* must fall as a synonym of *H. gelastops*; however, as noted below, there is a biological difference between the northern and southern populations of the species so defined.

The type specimen of *H. gelastops* was originally in the Kirkaldy collection (Kirkaldy 1902, p. 243). For *H. picta* no types were designated with the original description because Hunter et al did not intend their study to present *H. picta* as a new species; however, their description gained the authorship for them and permitted ready recognition of it. Carvalho (1955, p. 226) selected a San Antonio, Tex., female lectotype (USNM type 67964) from 83 "cotypes" in the U.S. National Museum collection.

As now understood, this is the most widespread species in the genus, occurring from Texas south to central Vera Cruz in Mexico.

Hunter et al placed this species ninth in a list of 13 of "The Principal Insects Injurious to Opuntia in Order of their Importance." They reported it attacking the joints between the pads: "The injury is not

conspicuous. It causes the plants to assume a spotted appearance, but, except where the bugs are unusually abundant, the joints recover. It is not a true cactus insect, but has been found upon a variety of other plants."

The occurrence on other plants may be due to a more general taste or may result from the nervous activity of a bug that flies quickly when disturbed. Observations of flying stages of insects resting on a plant should not be interpreted as indicating a host preference—any convenient object can serve as a resting perch. Nearly all ecological notes on specimens, including all immatures, associate these insects with *Opuntia* cactuses, some specimens being labelled from *O. engelmannii* specifically. The only exception was a series of four adults taken on May 18 from "castor beans" at Brownsville, Tex. These specimens were also a little shorter than the minimum figure given in the key, measuring 4.5 to 4.7 mm.

The data cited below show two periods of adult occurrence in Texas: April 12 to June 3 and later from September 5 to November 13. In contrast, the several Mexican specimens were taken during the intermediate summer period in July and August. Whether this timing is real or an artifact resulting from too few records will be decided only by more collecting in the appropriate areas.

Distribution: 133 specimens examined. UNITED STATES: TEXAS: Apr. 12–June 3, Sept. 5–Nov. 28; Austin, Bastrop, Brownsville, Calvert, Cameron, Corpus Christi, D'Hanis, Garner State Park, Hebbronville, Hondo, Laredo, Live Oak County, Luxello, Nueces, San Antonio, San Diego, Seguin, Sharpsburg, Uvalde, Victoria. MEXICO: SAN LUIS POTOSI: July; El Salto; TAMAULIPAS: July; Tampico; VERA CRUZ: August; Cordoba, Jalapa.

Hesperolabops mexica, new species

FIGURES 6, 11–16

The wholly fuscous hemelytra coupled with the calli being darkened only laterally and not dorsally will permit recognition of this species. The male is recognizable on characters of the genital capsule by the combination of no small slender hook laterad of the long, slender process on the posterodorsal angle and no hook at the apex of the right clasper.

Holotype male: length 7.05 mm; width across combined hemelytra 2.70 mm.

Head: dark red, strongly tumid frons (fig. 6) blackened; width across eyes 1.23 mm, between eyes 0.75 mm, between bases of eye stalks 0.25 mm; labium reaching to apex of fourth abdominal sternite, segments I–IV measuring 0.91, 1.00, 0.31, 0.26 mm respectively; antennae black, densely and finely pubescent, segments I–IV measuring

0.70, 1.74, 0.78, 0.56 (shrivelled) mm respectively. Pronotum: length 1.04 mm, width 1.94 mm; dorsal surface, including calli dorsally and broad central part of collar, orange red; deflexed lateral parts, except rounded impressions, and usually vertical lateral face of prominent calli fuscous to black; disc coarsely and closely punctate posterior to calli; each callus connected to collar by two ridges, a small oblique one near inner end and a longitudinal one at midwidth. Scutellum black with four basal impressions and mesoscutum red; surface not polished.

Hemelytra dull, opaque, fuscous, sometimes with bluish reflections; surface, except membrane, with numerous coarse, very shallow and obscure punctures, each bearing a short, fine, light bristle. Membrane and veins black, with a single large cell.

Ventral surface dark red, blackened on meso- and metapleura (except in rounded impressed areas) and along sides of abdomen. Legs, including tarsi, brownish to black; tarsi widening to apex.

Holotype male: Queretaro, Queretaro, Mexico, August 1963, F. D. Bennett, *Opuntia tomentosa* (USNM type 67965). Allotype female: Guanajuato, Mexico, Oct. 14, 1926, Mortensen, on *Opuntia*. Paratypes: three males (one missing head and prothorax) with same data as holotype; Morelia, Michoacan, Mexico, Oct. 19, 1926, Mortensen, on *Opuntia*, one male and two females (USNM and collection of F. D. Bennett).

The entire series is quite uniform, except that on old and teneral specimens the legs and hemelytra tend to be noticeably paler than on fresh, well-sclerotized individuals.

The species name is from "Mexico," an alternate name for the Aztec Indians, whose role in the area whence these specimens came was very great.

***Hesperolabops nigriceps* Reuter, new status**

FIGURES 17-21

Hesperolabops gelastops var. *nigriceps* Reuter, 1908, p. 152.

The uniformly fuscous hemelytra coupled with the distinct blackening of part or all of the dorsal surface of the calli separate *H. nigriceps* from the other species of the genus. Males can be recognized by modifications of the genital capsule, the character easiest to use being the presence of a small hook laterad of the base of the long process on the posterodorsal angle.

No type material of this species was examined; however, the description of the single type specimen, credited with being in the Vienna Naturhistorisches Museum, commented upon the unicolorous dark hemelytra and the infusate calli and left no doubt about applying the name to this form.

Ecological notes on specimens collected by F. D. Bennett cite them from *Opuntia megacantha* or simply *Opuntia*.

Distribution: While *H. nigriceps* was described from "Mexico," data from 29 specimens further restrict its known distribution to only two Mexican states near Mexico City. MEXICO: MEXICO: July, August, November; Chapingo. TLAXCALA: July; Calpulalpam.

***Hesperolabops periscopis* Knight**

FIGURES 27-31

Hesperolabops periscopis Knight, 1928, p. 67.

The dominantly red dorsum (except apical two-thirds of clavus, inner apical angles of coria, and membrane, all of which are fuscous) sets this species part from all others in the genus. The male is well marked by the long, thick, decurved spine on the margin of the genital capsule immediately above the insertion of the right clasper.

Hesperolabops periscopis was described from two females taken on Dec. 6, 1927, at La Union, El Salvador. The holotype female is in the United States National Museum (type no. 52833). A note accompanying the original description said, "This species was found commonly on both *Cerei* and *Opuntiae*."

Distribution: A good series of both sexes from the cactus *Acanthocereus horridus* (photograph of host identified by the late Dr. E. Yale Dawson, Smithsonian Institution) in the southernmost Mexican State of Chiapas agrees very well with the holotype and extends the distribution of the species north across Guatemala into southern Mexico. Exact collecting information on the specimens is as follows: "7 mi. N.W. Acala, Chiapas, Mexico, June 23, 1965, Burke, Mayer and Schaffner."

***Hesperolabops sanguineus* Carvalho, new status**

FIGURES 22-26

Hesperolabops gelastops var. a Reuter, 1908, p. 152.

Hesperolabops gelastops var. *sanguinea* Carvalho, 1957, p. 106.

The wholly red pronotum and scutellum coupled with the unicolorous fuscous to black hemelytra will delimit this species from all the others in the genus. The male is unique within the genus by possessing the long, slender, upturned hook at the end of the right clasper (fig. 24).

Crediting of the name "*sanguineus*" to Carvalho, as above, needs an explanation, especially since Carvalho in his "Catalog" credits it to Reuter. In Reuter's (1908, p. 152) treatment of Mexican specimens of this genus, two varieties of *gelastops* were described and

designated as "var. a" and "var. b." Reuter apparently intended to supply a name for each as he followed "var. b" with the name "*nigriceps* m." No name, however, appeared after the designation "var. a." The description of each variety began with a generalized color term—in the case of "var. a," this was "sanguinea." Carvalho, in assembling his catalog, apparently assumed this color term to be coordinate with "*nigriceps*" and used it accordingly. It is clear, however, that Reuter gave no name to this segregate and that Carvalho did; therefore, the authorship must be given to the latter.

The original description of three specimens in the Vienna Naturhistorisches Museum is inclusive enough to permit ready recognition of this species by the color characters stated above.

The original localities were Guadalupe and Orizaba, Mexico. Just which Mexican "Guadalupe" was involved is not stated; however, the Orizaba locality coupled with the present series of 13 specimens from Cuernavaca, Morelos, suggests that this species occurs only south and east of Mexico City.

The seven adults and six nymphs were captured during July and August from *Opuntia*, according to their collector, N. L. H. Krauss.

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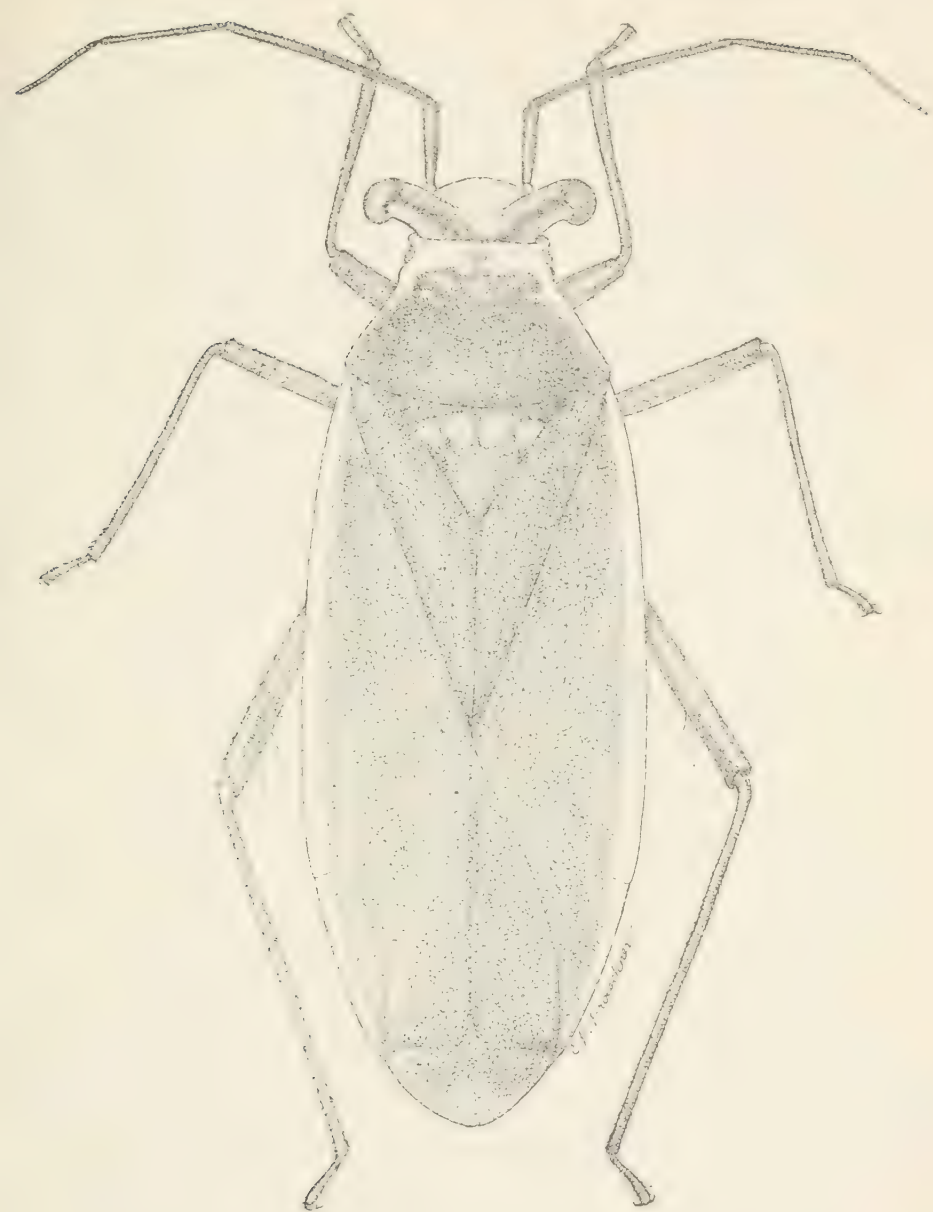
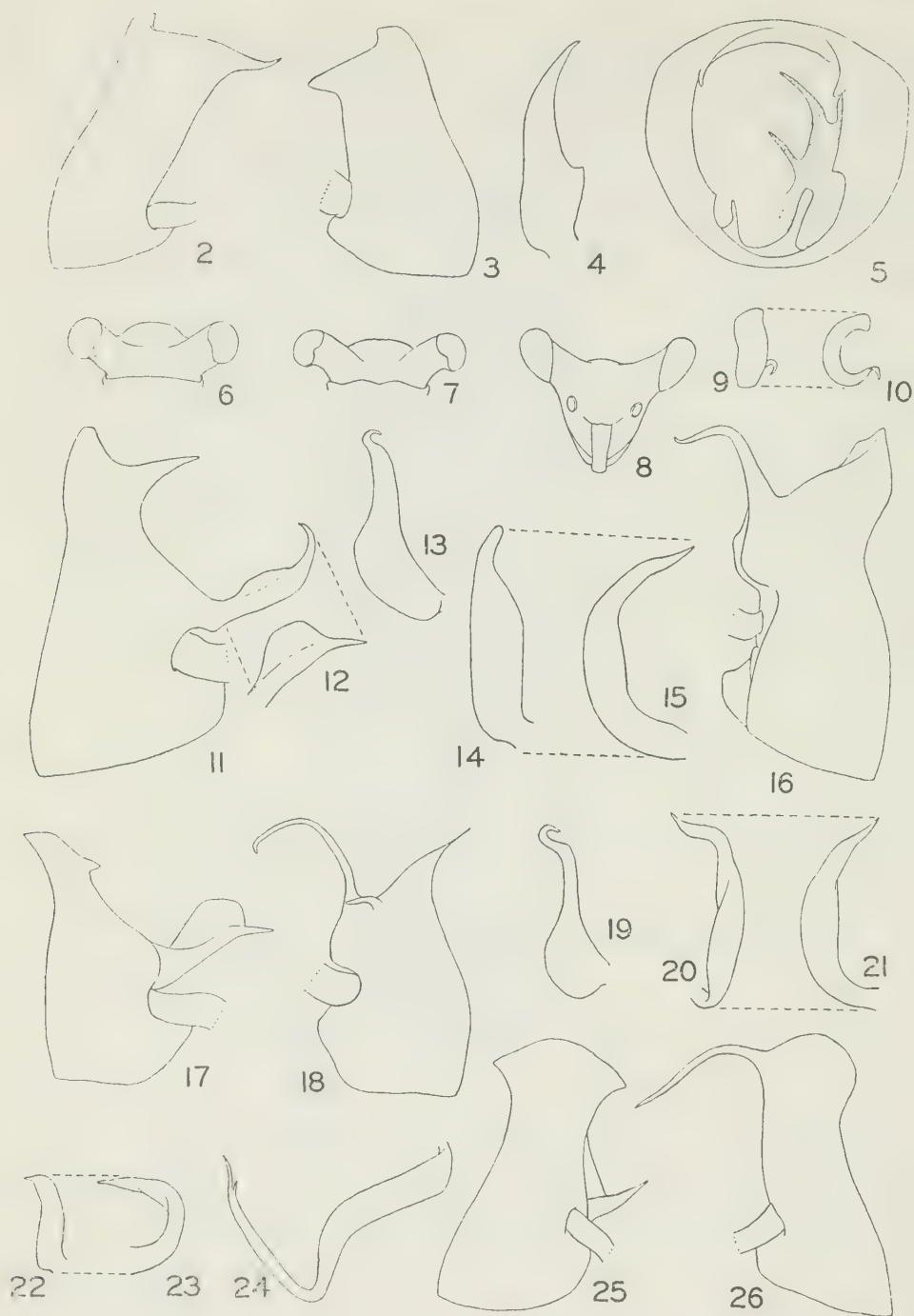
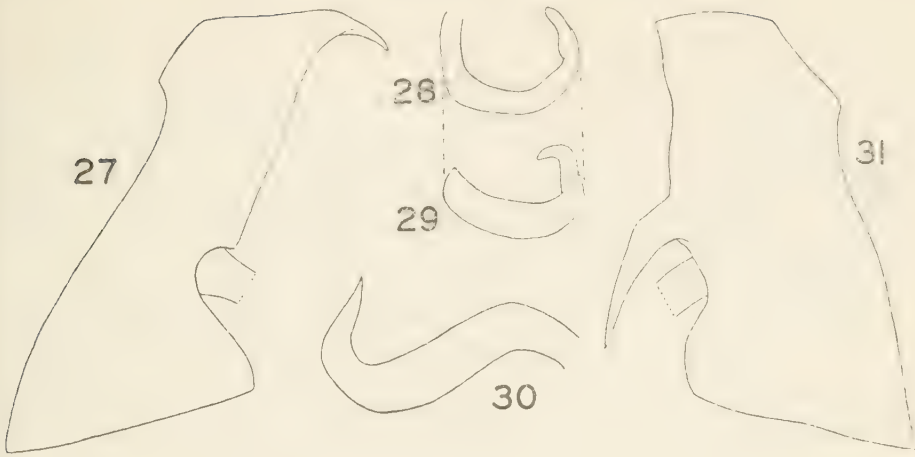


FIGURE 1.—*Hesperolabops gelastops*: general habitus, dorsal view.





FIGURES 27-31.—*Hesperolabops periscopis*: 27, genital capsule, left view; 28, 29, left clasper, dorsal and posterior views; 30, right clasper, posterior view; 31, genital capsule, right view.

FIGURES 2-26.—*Hesperolabops gelastops*: 2, 3, genital capsule, left and right views; 4, right clasper, lateral view; 5, genital chamber, posterior view. *Hesperolabops mexicana*: 6, head, dorsal view. *Hesperolabops gelastops*: 7, 8, head, dorsal and anterior view; 9, 10, left clasper, lateral and dorsal views. *Hesperolabops mexicana*: 11, 12, genital capsule, left view and projection of posterior process; 13, left clasper, lateral view; 14, 15, right clasper, lateral and dorsal views; 16, genital capsule, right view. *Hesperolabops nigriceps*: 17, 18, genital capsule, left and right views; 19, left clasper, lateral views; 20, 21, right clasper, ventral and lateral views. *Hesperolabops sanguinea*: 22, 23, left clasper, lateral and dorsal views; 24, right clasper, lateral view; 25, 26, genital capsule, left and right views (all genital structures to same scale).

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3615

Revision of the Genus *Harmstonia* (Diptera: Dolichopodidae)

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In a previous paper on the Dolichopodidae (1964), I described the genus *Harmstonia* and included in it two previously undescribed species occurring in the eastern United States. At that time a number of additional species were already known to occur in Mexico. More recently, specimens of a Costa Rican species have been obtained from the Melander Collection, which is now housed at the U.S. National Museum, and a West Indian species has been collected by various participants in the Bredin-Archbold-Smithsonian Biological Survey of the island of Dominica. In the present paper, descriptions and a key are provided for the 13 species now known in the genus.

Genus *Harmstonia* Robinson

Small, 1-2 mm long, dark metallic green with mostly dark bristles. Face of male grayish pollinose, extremely narrow in lower half, sides diverging above and continuous with diverging sides of the front; face of female somewhat wider with a few setae at the lower third; palpus dark with small hairs; pseudotracheae of the labellae rudimentary with irregular thickenings; antenna brown or black, all segments short; segment 1 bare above; segment 2 truncate; segment 3 blunt or short-pointed, with arista inserted dorsally; lower postocu-

lar setae uniseriate. Mesoscutum strongly arched with posterior slope distinctly flattened, with grayish or brownish pollen toward sides; acrostichals absent; 5 pairs of large dorsocentrals; 2 scutellars, a small hair on the lateral scutellar margin; pleural surface with grayish pollen. Femora with preapicals usually weak, sometimes not distinct. Longitudinal veins of wing straight to slightly curved, all, including veins 3 and 4, diverging for most of length; crossvein nearly as long as or longer than last part of vein 5; vein 6 totally absent. Calypter pale with dark margin and some dark setae. Abdomen short, tapering; hypopygium sessile, usually large and projecting somewhat forward under the abdomen.

Type-species: *H. intricata* Robinson, original designation.

The species occur on soil or rocks at edges of streams and lakes or on moist rock surfaces near seepage and waterfalls. They sometimes alight but more frequently hover close to the surface of the substrate. The species may be very particular regarding positions where they alight and the males of some species seem to favor slightly different habitats from the females.

Most collections of *Harmstonia* have come from limestone regions. The genus is apparently absent from regions of North Carolina where limestone is conspicuously lacking. Recently I have collected *H. intricata* along a stream flowing over aged serpentine but pH was not checked. One species is found on the West Indian island of Dominica, which is primarily volcanic in origin, but the Dominican streams that have been tested show a rather high pH.

Key to the Species of *Harmstonia*

1. Foretibia with a distinct row of anterodorsals, hind tibia usually with a distinct row of posterodorsals; hypopygial lamella broadly oval or elliptical and rounded apically 2
Fore- and hind tibiae without rows of prominent dorsals; hypopygial lamellae (except *H. intricata*) bearing obvious slender apical projections 7
2. Hind tibia with short stout black apical and subapical setae; hypopygial lamella covered with hairs; face of female bearing two distinct setae . . 3
Hind tibia without distinct black apicals and subapicals; surface of hypopygial lamella glabrous; face of female with three to six distinct setae . . 4
3. Femora blackish; middle tibia with two anterodorsals; abdomen of male straight (Mexico) ***H. recta***, new species
Legs including femora yellow; middle tibia with one anterodorsal; abdomen of male curved (Mexico) ***H. pubescens***, new species
4. Legs totally brown; body and wings both over 1.5 mm long; hypopygium large, over 0.5 mm long (Mexico) ***H. megalopyga***, new species
Legs partly yellow; body and wings less than 1.25 mm long; hypopygium distinctly less than 0.5 mm long 5
5. Knob of halter pale (Mexico) ***H. ornata***, new species
Knob of halter black or brown 6

6. Male hind tibia with a row of indistinct posterodorsals, hind femur with sparse slender setae along posteroventral surface (Costa Rica).

H. costaricensis, new species

Male hind tibia with a row of very prominent posterodorsals, hind femur with many close-set setae along distal half of posteroventral surface (Mexico) H. setosa, new species
7. Knob of halter black or brown, rarely pale brown; hypopygial lamella bearing branched setae 8
Knob of halter yellow; hypopygial lamella without branched setae 9
8. Hypopygium over 1/2 as long as the body, bearing large lamellae; hind femur of the male bearing a fringe of short setae along the anteroventral surface (eastern U.S., Mexico) H. pectinicauda Robinson
Hypopygium about 1/4 as long as the body, bearing very small lamellae; male hind femur without evident fringe anteroventrally (Dominica).

H. simplex, new species
9. Legs mostly or wholly brown. 10
Legs mostly yellow 11
10. Hypopygium bearing large pale rounded lamellae; all femora of the male fringed with long hairs ventrally; face of female with two large setae (eastern U.S.) H. intricata Robinson
Hypopygial lamellae mostly blackish and bearing projections apically; femora of male without distinct setae ventrally; face of female with three to four setae (Mexico) H. obscura, new species
11. Front with yellowish gray pollen; antennal segment 3 rounded; abdomen of male only slightly curved downward, hypopygium usually borne under the tip; face of female with two or rarely three setae (Mexico).

H. pallida, new species

Front with brown pollen; antennal segment 3 truncate apically; abdomen of male curved distinctly downward with hypopygium borne on tip; face of female with four small setae 12
12. Hypopygial lamella ending in a long attenuate tip (Mexico).

H. attenuata, new species

Hypopygial lamella ending in a short hooklike point (Mexico).

H. clavicauda, new species

The genus can be divided into three rather distinct groups.

Group I (Typical)

Legs bearing only weak setae, hypopygial lamellae bearing slender projections or a bulbous base. The group contains the following seven species.

Harmstonia intricata Robinson

FIGURES 1, 14

Harmstonia intricata Robinson, 1964, p. 123 [type-species by original designation].

MALE.—Length 1.15 mm; wing 1.32 mm by 0.51 mm. Front grayish yellow; antennal segment 3 (fig. 14) short, truncate to slightly rounded below. Basitarsi except tips pale, legs otherwise brown; all femora fringed with long setae below, middle and hind femora with

weak preapicals; fore- and hind tibiae without prominent dorsals or apicals, middle tibia with a weak anterodorsal and a weak posterodorsal near basal third; lengths of segments of foretarsus from base as .16-.09-.06-.05-.06 mm; middle tarsus as .21-.09-.07-.05-.05 mm; hind tarsus as .16-.14-.09-.06-.06 mm. Tips of wing veins 2 and 3 are $1\frac{1}{2}$ times as far apart as tips of veins 3 and 4, vein 3 very slightly curved to become nearly parallel with 4 distally; crossvein as long as last of vein 5; knob of halter pale yellow. Hypopygium (fig. 1) ca. .35 mm long; hypopygial lamella broad and rounded apically, with bulging pale inflated area at base, with a slender inward projection from middle of lower margin.

FEMALE.—Face bearing two large setae; femora without long setae below.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Knox County, Tenn. (USNM 69429).

DISTRIBUTION.—*H. intricata* is known only from the eastern U.S., having been collected in eastern Tennessee, northern Virginia, Maryland, and central New York.

NOTES.—The hypopygial lamellae of *H. intricata* are unique for Group I in having a broad rounded apical portion and lacking any slender apical projections. The pale bulbous region of the lamella base, however, clearly relates *H. intricata* to other species in the group. Such a hyaline or bulbous area is present to some extent in most species of the group and is particularly well developed in *H. pectinicauda*. In all cases the surface of this hyaline or bulbous area bears some scattered setae.

While collecting specimens from a muddy rut at the type-locality in Tennessee, I noticed that the males were collected from the drier parts of the rut, but females were apparently restricted to the part containing some standing water.

Harmstonia pectinicauda Robinson

FIGURES 2, 15

Harmstonia pectinicauda Robinson, 1964, p. 123.

MALE.—Length 1.00 mm; wing 1.17 mm by 0.42 mm. Front brownish or grayish; antennal segment 3 (fig. 15) short, nearly truncate, lower part projecting forward somewhat beyond end of dorsal edge. Basitarsi except tips and tibiae pale, legs otherwise brown; hind femur with distinct row of short setae along anteroventral surface, middle and sometimes hind femur with weak preapical; fore- and hind tibiae without prominent dorsals or apicals, middle tibia with a weak anterodorsal and a weak posterodorsal near basal third; lengths of segments of foretarsus from base as .13-.07-.06-

.05-.06 mm; middle tarsus as .17-.08-.06-.04-.06 mm; hind tarsus as .13-.14-.09-.07-.07 mm. Tips of wing veins 2 and 3 are $1\frac{1}{4}$ times as far apart as tips of veins 3 and 4, vein 3 only very slightly curved and not becoming parallel with 4 distally; crossvein as long as or slightly longer than last of vein 5; knob of halter blackish or rarely brownish. Hypopygium (fig. 2) ca. .36 mm long; hypopygial lamella mostly brownish, long and slender, bearing numerous branched setae, with bulging pale inflated area at base, with a small hooked projection on the lower margin.

FEMALE.—Face bearing two large setae; hind femur without distinct setae along anteroventral surface.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Frederick County, Va. (USNM 66492).

DISTRIBUTION.—*H. pectinicauda* has been collected both in the United States, from northern Virginia, and in Mexico, from San Luis Potosi, Hidalgo, Veracruz, Guerrero, Oaxaca, and Chiapas.

NOTES.—Specimens mounted on microscope slides show a crest of five small setae ventrally on the hind trochanter. The other species I have mounted on slides do not show such setae.

The Mexican specimens seem like those from Virginia in all details of structure but the tibiae tend to be paler. Three specimens from El Salto in San Luis Potosi show pale brown rather than black knobs on the halters.

Among the Virginia specimens the males were obtained only in direct sunlight. Females seemed to have no preference.

Harmstonia simplex, new species

FIGURES 3, 16

MALE.—Length 1.00 mm; wing 1.17 mm by 0.42 mm. Front brown; antennal segment 3 (fig. 16) shortly acute. Trochanters, distal parts of tibiae, and bases of basitarsi pale, legs otherwise brown; middle and hind femora with a few longer setae along ventral surfaces, middle femur with a weak preapical; fore- and hind tibiae without prominent dorsals or apicals, middle tibia with a weak anterodorsal and a weak posterodorsal near basal third; lengths of segments of foretarsus from base as .13-.07-.06-.05-.06 mm; middle tarsus as .17-.11-.07-.06-.06 mm; hind tarsus as .13-.15-.09-.06-.06 mm. Tips of wing veins 2 and 3 are $1\frac{1}{4}$ times as far apart as tips of veins 3 and 4, veins 3 and 4 essentially straight and not becoming nearly parallel; crossvein about as long as last of vein 5; knob of halter black or brown. Hypopygium (fig. 3) ca. .25 mm long; hypopygial lamella rather brownish, small and slender, bearing small branched setae, with small pale somewhat bulging area at base, with a small hooked projection on the lower margin.

FEMALE.—Face bearing two small setae, antennal segment 3 (fig. 16) blunt; femora without distinct setae along ventral surfaces.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Dominica: Clarke Hall, Feb. 11–20, 1965, W. W. Wirth (USNM 69430). Paratypes: Clarke Hall (including specimens from Manets Guter, coconut grove, cocoa trail, and specimens from light and malaise traps) Jan. 8–Mar. 20, 18 ♂, 23 ♀; Macoucheri River, Jan. 14, 12 ♂; Macoucheri River, seashore and river mouth, Mar. 15, 5 ♂; Cabrits Swamp, Feb. 2–3, Mar. 22–25, 2 ♀; Fond Figes, Feb. 9, Mar. 9–12, 4 ♂, 1 ♀; Hodges River mouth, Feb. 27, 1 ♂, 2 ♀; Woodford Hill, Feb. 27, swamp forest, 1 ♂; all from Dominica, 1965, W. W. Wirth. Additional paratypes: Clarke Hall, Jan. 22–29, 21 ♂, 42 ♀; same locality, Feb. 28, 2 ♂; Deux Branches, Pagua River, Feb. 3, 3 ♂, 3 ♀; near Belfast, Jan. 31, 1 ♂; all from Dominica, 1964, H. Robinson.

NOTE.—*H. simplex* is the only species of *Harmstonia* in which I have observed distinct sexual dimorphism of the third antennal segment.

Harmstonia obscura, new species

FIGURE 4

MALE.—Length 1.00 mm; wing 1.17 mm by 0.42 mm. Front brown; antennal segment 3 short, rounded. Legs brown; middle femur with a weak preapical; fore- and hind tibiae without prominent dorsals or apicals, middle tibia with a weak anterodorsal and a weak posterodorsal near basal third; lengths of segments of foretarsus from base as .11–.05–.04–.04–.05 mm; middle tarsus as .15–.06–.05–.04–.05 mm; hind tarsus as .13–.13–.08–.05–.06 mm. Tips of wing veins 2 and 3 are $1\frac{1}{4}$ times as far apart as tips of veins 3 and 4, veins 3 and 4 essentially straight and not becoming nearly parallel; crossvein 1 to $1\frac{1}{4}$ times as long as last of vein 5; knob of halter yellow. Hypopygium (fig. 4) ca. .25 mm long; hypopygial lamella blackish, broad with two prominent distal projections, with a small hyaline area in middle of base.

FEMALE.—Face bearing four, rarely three, small setae.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Mexico: Chiapas, near junction of Rts. 190 and 200, May 21, 1963, H. Robinson (USNM 69431). Paratypes: same data as holotype, 7 ♂ and 3 ♀; Guerrero, Rio Papagayo near Tierra Colorado, May 29, 1963, H. Robinson, 1 ♀.

Harmstonia pallida, new species

FIGURE 5

MALE.—Length 1.00 mm; wing 1.25 mm by 0.49 mm. Front yellowish gray; antennal segment 3 short, rounded. Tarsi from

tips of basitarsi brownish, legs otherwise yellow; middle femur with a weak preapical; fore- and hind tibiae without prominent dorsals or apicals, middle tibia with a weak anterodorsal and a weak posterodorsal near basal third; lengths of segments of foretarsus from base as .15-.06-.05-.05-.06 mm; middle tarsus as .19-.10-.08-.06-.07 mm; hind tarsus as .15-.17-.11-.08-.07 mm. Tips of wing veins 2 and 3 twice as far apart as tips of veins 3 and 4, vein 3 rather distinctly bending and becoming parallel with vein 4 distally; crossvein about as long as last of vein 5; knob of halter yellow. Hypopygium (fig. 5) ca. .21 mm long; hypopygial lamella pale, with a narrow pointed tip and slightly inflated base.

FEMALE.—Face bearing two or three small setae.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Mexico: San Luis Potosi, El Salto, on limestone deposits in river below upper falls, May 9, 1963, H. Robinson (USNM 69432). Paratypes: same data as holotype, 18 ♂ and 18 ♀.

NOTES.—*H. pallida*, in spite of superficial resemblance to *H. attenuata* and *H. clavicauda*, seems more closely related to *H. pectinicauda* and *H. simplex*. The rounded third antennal segment of *H. pallida* seems rather distinctive. The antenna of *H. obscura* seems similar, but that species is very different in other characters including the structure of the hypopygial lamella.

Harmstonia attenuata, new species

FIGURE 6

MALE.—Length 1.06 mm; wing 1.17 mm by 0.42 mm. Front brown; antennal segment 3 not visible. Tarsi from tips of basitarsi brownish, legs otherwise yellow; middle femur with a weak preapical; fore- and hind tibiae without prominent dorsals or apicals, middle tibia with a weak anterodorsal and a weak posterodorsal near basal third; lengths of segments of foretarsus from base as .13-.06-.05-.05-.06 mm; middle tarsus as .17-.08-.06-.05-.06 mm; hind tarsus as .13-.17-.11-.08-.07 mm. Tips of wing veins 2 and 3 are $1\frac{1}{2}$ to 2 times as far apart as tips of veins 3 and 4, vein 3 bending slightly and becoming nearly parallel with vein 4 distally; crossvein slightly shorter than last of vein 5; knob of halter yellow. Abdomen curving distinctly downward; hypopygium (fig. 6) mounted directly on apex of abdomen, ca. .25 mm long; hypopygial lamella with a very long and narrow tip, bearing a few slender projections on distal part of lower edge, with a large densely pubescent lobe near base, without inflated area at base.

FEMALE.—Face bearing four small setae; antennal segment 3 short and truncate apically.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Mexico: Guerrero, Rio Papagayo near Tierra Colorado, May 29, 1963, H. Robinson (USNM 69433). Paratypes: same data as holotype, 7 ♀.

NOTES.—*H. attenuata* is related very closely to the more widely distributed *H. clavicauda*, showing among other things the same curved abdomen with the more apically positioned hypopygium, and similar pubescent lobes on uninflated bases of the hypopygial lamellae. The only obvious difference between the species is in the very differently shaped apex of the hypopygial lamellae. At present I know of no differences between the females of the two species and I cannot be certain the associated females are not specimens of *H. clavicauda*. When more male specimens are available, the lack of distinct dorsals on the hind tibia as seen in the holotype may prove to be significant.

Harmstonia clavicauda, new species

FIGURE 7

MALE.—Length 1.00 mm; wing 1.17 mm by 0.42 mm. Front brown; antennal segment 3 short, rather obliquely truncate with lower corner somewhat produced. Bases of coxae and tarsi from tips of basitarsi brownish, femora very slightly infuscated, legs otherwise yellow; middle femur with a weak preapical; middle tibia with a weak anterodorsal and a weak posterodorsal near basal third, hind tibia with a few weak dorsals, tibiae otherwise without prominent dorsals or apicals; lengths of segments of foretarsus from base as .13-.05-.05-.05-.05 mm; middle tarsus as .19-.11-.08-.06-.06 mm; hind tarsus as .13-.19-.11-.07-.06 mm. Tips of wing veins 2 and 3 are $1\frac{1}{2}$ to $1\frac{1}{2}$ times as far apart as tips of veins 3 and 4, vein 3 bending slightly and becoming nearly parallel with vein 4 distally; crossvein $\frac{2}{3}$ as long as, to as long as, last of vein 5; knob of halter yellow. Abdomen curving distinctly downward; hypopygium (fig. 7) mounted directly on apex of abdomen, ca. .21 mm long; hypopygial lamella with a short hooked tip, with a large densely pubescent lobe on lower margin, without inflated area at base.

FEMALE.—Face bearing four small setae.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Mexico: Chiapas, May 22, 1963, H. Robinson (USNM 69434). Paratypes: same data as holotype, 1 ♂ and 1 ♀; Veracruz, near Santiago Tuxtla, Aug. 8, 1962, 6 ♂ and 2 ♀; Morelos, near Cuernavaca, May 28, 1963, 2 ♂ and 3 ♀; all collected by H. Robinson.

Group II

Tibiae bearing strong setae or distinct rows of setae, hind tibia without distinct apicals or ventrals, hypopygial lamellae broadly oval

to elliptical with the surface glabrous. The group contains the following four species.

Harmstonia megalopyga, new species

FIGURE 8

MALE.—Length 1.60 mm; wing 1.60 mm by 0.57 mm. Face very narrow but distinct to the mouth, whitish pollinose; front grayish; antennal segment 3 short, truncate with lower corner slightly produced. Legs brown to blackish; middle femur with preapical, hind femur with preapical often preceded by second smaller seta and with row of distinct setae along anteroventral surface; foretibia with five to six slender anterodorsals, middle tibia with a large anterodorsal and a large posterodorsal near basal third, hind tibia with eight or more slender posterodorsals, tibiae without distinct apicals; lengths of segments of foretarsus from base as .25-.12-.06-.06-.08 mm, basitarsus with about five slender erect setae below; middle tarsus as .23-.11-.08-.05-.07 mm; hind tarsus as .17-.21-.11-.08-.08 mm. Tips of wing veins 2 and 3 are $1\frac{1}{4}$ times as far apart as tips of veins 3 and 4, veins 2 and 3 curved slightly back distally, vein 4 curved slightly forward and becoming parallel with vein 3 distally; crossvein $1\frac{1}{2}$ to $1\frac{1}{2}$ times as long as last of vein 5; knob of halter fuscous yellow. Hypopygium (fig. 8) ca. .65 mm long; hypopygial lamella elliptical from a tapered base, pale and nearly hyaline, outer or lower margin bearing a fringe of long setae, a pair of large black marginal setae from near base, cucullate tip of lamella with a small included appendage.

FEMALE.—Face bearing four to six rather strong setae, rarely only three; hind femur without distinct setae below.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Mexico: San Luis Potosi, small ravine a few km south of Tamazunchale, on surface of moist limestone, Aug. 4-5, 1962, H. Robinson (USNM 69435). Paratypes: same data as holotype, 2 ♂ and 4 ♀; Chiapas, Ixtapan, on moist limestone at roadside above river, May 23, 1963, H. Robinson, 1 ♂ and 3 ♀.

NOTES.—The species is the largest known in the genus. In addition, the hypopygium is disproportionately large.

The elliptical cucullate hypopygial lamella as seen in this group seems homologous to the inflated basal area evident in most of the species of Group I. The small included apical lobe found in the *H. megalopyga* group seems homologous to the apical part of the lamella that is prominent in the species of Group I.

Harmstonia setosa, new species

FIGURE 9

MALE.—Length 1.21 mm; wing 1.21 mm by 0.50 mm. Front gray; antennal segment 3 short, rather truncate, rounded and slightly produced below. Trochanters, tibiae, and all but tips of basitarsi yellowish, legs otherwise brown; middle femur with preapical; hind femur with many close-set long setae along distal half of posteroventral surface; foretibia with two to three slender anterodorsals, middle tibia with a large anterodorsal and a large posterodorsal near basal third, hind tibia with 5 prominent posterodorsals, tibiae without distinct apicals; lengths of segments of foretarsus from base as .18-.09-.07-.05-.05 mm; middle tarsus as .21-.09-.07-.05-.06 mm; hind tarsus as .15-.18-.12-.07-.07 mm. Tips of wing veins 2 and 3 are $1\frac{1}{2}$ times as far apart as tips of veins 3 and 4, vein 3 curved slightly backward to become nearly parallel with vein 4 distally; crossvein slightly longer than last of vein 5; knob of halter blackish. Hypopygium (fig. 9) ca. .36 mm long; hypopygial lamella oval from a tapered base, pale and nearly hyaline, surface glabrous, outer margin bearing a fringe of long setae, cucullate tip of lamella bearing a large falcate appendage toward inside.

FEMALE.—Face bearing three to four setae, upper 1 or 2 usually smaller; hind femur without distinct setae posteroventrally.

TYPE-DATA.—Holotype ♂ from Mexico: Hidalgo, near Chapulhuacan, on wet rock face above roadside spring, Aug. 5, 1962, H. Robinson (USNM 69436). Allotype ♀: same locality, Aug. 13, 1962. Paratypes: same locality as holotype, Aug. 5, 13, 1962, 10 ♂ and 8 ♀; San Luis Potosi, a few km south of Tamazunchale, on moist limestone in small ravine, Aug. 4, 1962, 1 ♂; all collected by H. Robinson.

Harmstonia costaricensis, new species

FIGURE 10

MALE.—Length 1.00 mm; wing 1.25 mm by 0.49 mm. Front brownish gray; antennal segment 3 short, obliquely truncate with lower corner projecting. Tarsi from tip of basitarsi brownish, femora and bases of coxae slightly infuscated, legs otherwise yellowish; middle and hind femora with preapical, hind femur with sparse longer setae along posteroventral surface; foretibia with four black anterodorsals, middle tibia with a large anterodorsal and a large posterodorsal near basal third, hind tibia with two to six weak posterodorsals; lengths of segments of foretarsus from base as .17-.06-.05-.04-.05 mm; middle tarsus as .19-.08-.06-.04-.06 mm; hind tarsus as .13-.14-.08-.06-.07 mm. Tips of wing veins 2 and 3 are $1\frac{1}{2}$ times as far apart as tips of veins 3 and 4, veins 2 and 4 essentially straight, vein 3 slightly

curved and becoming nearly parallel with vein 4 distally; crossvein as long as last of vein 5; knob of halter black. Hypopygium (fig. 10) ca. .32 mm long; hypopygial lamella oval from a tapered base, pale and nearly hyaline, surface glabrous, outer margin bearing a fringe of long setae, cucullate tip of lamella bearing a large falcate appendage toward inside.

FEMALE.—Unknown.

TYPE-DATA.—Holotype ♂ from Costa Rica: La Suiza de Turrialba, July 1922, Pablo Schild (USNM 69437). Paratypes: same data as holotype, 3 ♂; all in A. L. Melander Collection in USNM.

NOTES.—*H. costaricensis* is very closely related to *H. setosa* of Mexico; nevertheless, there are slight but consistent differences in the form of the hypopygial lamella and in the pubescence of the hind femur. There also seem to be slight differences in the form of the third antennal segment. The legs of *H. costaricensis* seem rather pale but this may be partly due to the age of the specimens.

Harmstonia ornata, new species

FIGURE 11

MALE.—Length 1.17 mm; wing 1.37 mm by 0.49 mm. Front grayish; antennal segment 3 short, rather truncate, rounded and slightly produced below. Trochanters, knees, and basitarsi except tips yellow, legs otherwise brownish to blackish; middle and hind femora with a small preapical, without noticeable distinct ventral setae; foretibia with five or more slender anterodorsals, middle tibia with a large anterodorsal and a large posterodorsal near basal third, hind tibia with six or more slender posterodorsals, tibiae without distinct apicals; lengths of segments of foretarsus from base as .17-.08-.06-.04-.06 mm; middle tarsus as .19-.08-.06-.04-.06 mm; hind tarsus as .15-.19-.11-.06-.08 mm. Tips of wing veins 2 and 3 are $1\frac{1}{4}$ times as far apart as tips of veins 3 and 4, vein 3 curved slightly backward to become nearly parallel with vein 4 distally; crossvein as long as to slightly longer than last of vein 5; knob of halter yellow, stalk infuscated. Hypopygium (fig. 11) ca. .32 mm long; hypopygial lamella elliptical from a tapered base, pale brownish, in part nearly hyaline, surface glabrous, outer margin bearing a few prominent setae along distal part, most basal of these setae very long and thickened toward the tip, cucullate tip of lamella bearing a small included appendage.

FEMALE.—Face bearing usually three, more rarely up to five, small setae.

TYPE-DATA.—Holotype ♂ and allotype ♀ from Mexico: Guerrero, May 29, 1963, H. Robinson (USNM 69438). Paratypes: same data as holotype, 6 ♂ and 3 ♀.

NOTE.—The male of *H. ornata* is recognizable easily by the long retrorsely directed setae on the hypopygial lamella with one of the setae having an enlarged tip.

Group III

Tibiae bearing strong setae or distinct rows of setae, hind tibia with distinct apicals or ventrals, hypopygial lamellae broad with hairs on the surface. The group contains the following two species.

Harmstonia recta, new species

FIGURE 12

MALE.—Length 1.25 mm; wing 1.60 mm by 0.27 mm. Face very narrow but distinct to mouth; front grayish; antennal segment 3 short, rather truncate with lower corner slightly projecting. Trochanters, tibiae, and bases of fore- and middle basitarsi pale, legs otherwise brown to blackish; middle and hind femora with a preapical bristle, hind femur with setae somewhat longer along antero- and posteroventral surfaces; foretibia with three stout anterodorsals and an apical ventrally, middle tibia with an anterodorsal and a postero-dorsal near basal third, an anterodorsal near distal third, three distinct apicals of which ventral 2 are larger, hind tibia with an anterodorsal near tip, five stout posterodorsals, three stout antero-ventrals along distal half, a series of erect hairs posteroventrally that seem to continue along basitarsus, three apicals; lengths of segments of foretarsus from base as .19-.11-.06-.04-.06 mm; middle tarsus as .20-.09-.06-.04-.06 mm; hind tarsus as .17-.19-.09-.05-.07 mm. Tips of wing veins 2 and 3 are $1\frac{1}{3}$ to $1\frac{1}{2}$ times as far apart as tips of veins 3 and 4, vein 3 curved slightly backward to become nearly parallel with vein 4 distally; crossvein $1\frac{1}{4}$ to $1\frac{1}{2}$ times as long as last of vein 5; knob of halter yellow. Abdomen straight, hypopygium (fig. 12) ca. .32 mm long, directed downward; hypopygial lamella rather triangular, yellowish, bearing hairs on surface and longer hairs along margin.

FEMALE.—Face bearing two slender setae; hind femur without longer ventral setae.

TYPE-DATA.—Holotype ♂ from Mexico; Hidalgo, near Chapulhuacan, on wet rock face above roadside spring, Aug. 5, 1962, H. Robinson (USNM 69439). Allotype ♀: San Luis Potosi, a few km south of Tamazunchale, on moist limestone in small ravine, Aug. 4, 1962, H. Robinson. Paratypes: same locality as holotype, Aug. 5, 13, 10 ♂; same locality as allotype, Aug. 4, 5, 2 ♀; all in 1962, collected by H. Robinson.

NOTE.—*H. recta* is distinct from all other known species of the genus by having two rather than single anterodorsals on the middle tibiae.

Harmstonia pubescens, new species

FIGURE 13

MALE.—Length 1.30 mm; wing 1.80 mm by 0.33 mm. Face distinct to mouth, broadest of genus; front slightly brownish gray; antennal segment 3 very short, truncate. Tarsi from tips of basitarsi brownish, legs including coxae otherwise yellow; middle and hind femora with a preapical and with series of somewhat longer setae along anteroventral surfaces; foretibia with four to five stout black anterodorsals and a small apical ventrally, middle tibia with a large anterodorsal near middle and a large posterodorsal near basal third, two rather large apicals ventrally, hind tibia with an anterodorsal near tip, six stout black posterodorsals, two distinct ventrals at apex; lengths of segments of foretarsus from base as .15-.09-.07-.05-.07 mm; middle tarsus as .19-.13-.08-.06-.08 mm; hind tarsus as .15-.23-.13-.11-.08 mm. Tips of wing veins 2 and 3 are $1\frac{1}{2}$ times as far apart as tips of veins 3 and 4, vein 3 curved slightly backward to become nearly parallel with vein 4 distally; crossvein $1\frac{1}{4}$ times as long as last of vein 5; knob of halter yellow. Hypopygium (fig. 13) ca. .32 mm long; hypopygial lamella very large, rather rounded, pale yellowish, in part nearly hyaline, bearing small hairs along the margin and on the surface.

FEMALE.—Unknown.

TYPE-DATA.—Holotype ♂ from Mexico: Chiapas, about 10 km southwest of Pichucalco, small roadside waterfall, on petiole of dead leaf on wet ledge, May 24, 1963, H. Robinson (USNM 69440). Paratypes: same data as holotype, 6 ♂.

NOTES.—Though closely related to *H. recta*, *H. pubescens* can be distinguished easily by the lack of a straight abdomen, by the larger rounded hypopygial lamellae, and by the generally yellower legs, in addition to having only the single anterodorsal on the middle tibia.

I consider that *H. recta* and *H. pubescens* represent a very distinct group within the genus. The setae of the tibiae and the broad hypopygial lamellae indicate relationship with Group II but details of structure of the hypopygial lamellae are very different. The lamellar structure of the Group III species does not suggest homology with the bulbous basal part of the *H. intricata* lamella.

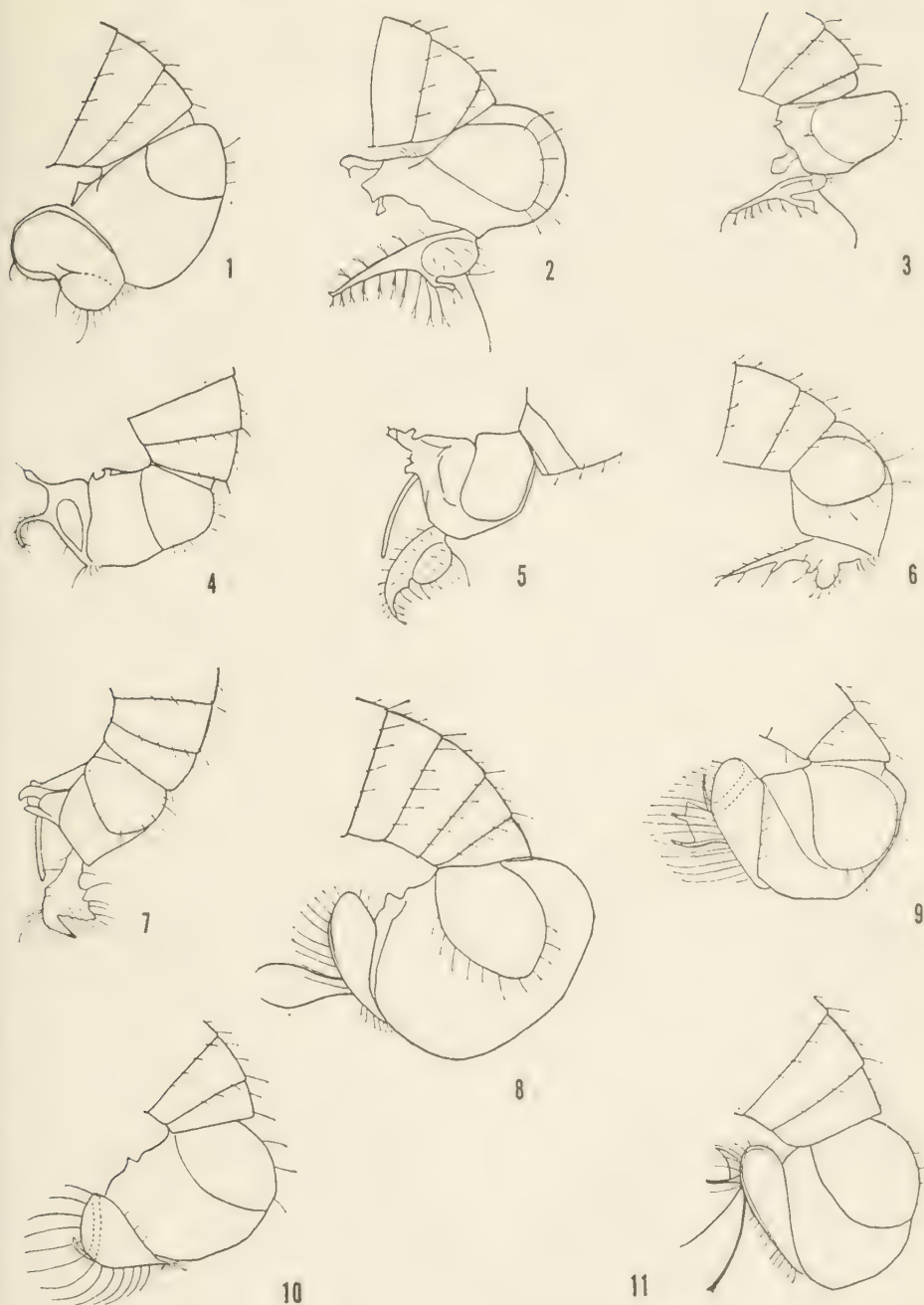
All the specimens of *H. pubescens* were collected from the same

leaf petiole. Almost as soon as one was caught, another would alight. When the leaf was turned accidentally so that the petiole no longer stood up, no more specimens could be found until the leaf was returned to its original position.

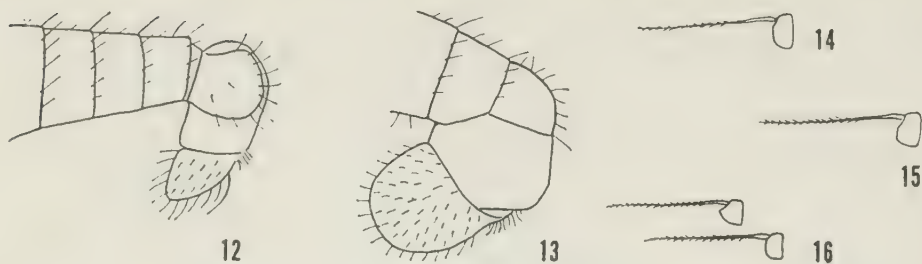
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FIGURES 1-11.—*Harmstonia*, hypopygia: 1, *H. intricata* Robinson; 2, *H. pectinicauda* Robinson; 3, *H. simplex*, new species; 4, *H. obscura*, new species; 5, *H. pallida*, new species; 6, *H. attenuata*, new species; 7, *H. clavicauda*, new species; 8, *H. megalopyga*, new species; 9, *H. setosa*, new species; 10, *H. costaricensis*, new species; 11, *H. ornata*, new species.



FIGURES 12-16.—*Harmstonia*, hypopygia and antennae: 12, *H. recta*, new species; 13, *H. pubescens*, new species; 14, *H. intricata* Robinson, male; 15, *H. pectinicauda* Robinson, male; 16, *H. simplex*, new species, male and female.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3616

A Review of the Genus *Euparixia* With Description of a New Species From Nests of Leaf-Cutting Ants in Louisiana (Coleoptera: Scarabaeidae)¹

By Robert E. Woodruff and Oscar L. Cartwright²

The scarabaeid beetles of the genus *Euparixia* are exceedingly rare in collections, probably due to their inquilinous habits. Because of their rarity, Woodruff was elated to receive from Dr. John C. Moser the first Louisiana specimen of this genus, taken near Flatwoods, La., in a nest of the leaf-cutting ant, *Atta texana* (Buckley) (pls. 1, 2). Since only one species has been known to occur in the United States (in Arizona), this specimen was studied critically.

Subsequently, additional specimens were collected by Dr. Moser and forwarded to Cartwright for study. The authors agreed that these specimens represented an undescribed species and undertook a thorough treatment of the genus. During the course of this study, holotypes or paratypes were examined of all species except *E. duncani* Brown, for which topotypic examples were studied.

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We wish to thank the following persons for assistance with this study and for the loan of specimens (abbreviations in parentheses are used in distribution records, which are quoted directly from museum labels under "Specimens Examined"): Dr. George W. Byers, Snow Entomological Museum, University of Kansas, Lawrence, Kansas (UK); Jose Carillo, Instituto Nacional Investigaciones Agricolas, Chapingo, Mexico (INIA); Dr. I. J. Cantrall, University of Michigan, Museum of Zoology, Ann Arbor, Michigan (UMMZ); Dr. P. J. Darlington, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts (MCZ); Dr. Henry F. Howden, Canadian National Collection, Ottawa, Canada (CNC); J. N. Knull, Ohio State University, Columbus, Ohio (OSU); Hugh B. Leech, California Academy of Science, San Francisco, California (CAS); Dr. Milton W. Sanderson, Illinois Natural History Survey, Urbana, Illinois (INHS); Dr. Richard B. Selander, University of Illinois, Urbana, Illinois (UI); Dr. A. M. Villiers, Museum National d'Histoire Naturelle, Paris, France (MNHP); Dr. F. G. Werner, University of Arizona, Tucson, Arizona (UA); and Ing. Fernando de Zayas, Havana, Cuba (Z). We would especially like to thank Dr. John C. Moser, Southeastern Forest Experiment Station, Alexandria, La., for specimens and information on the new species.

BIOLOGY AND ECOLOGY.—It is not surprising that very little information is available on the biology of insects such as *Euparixia*, which have restricted and secretive habits. Fewer than 50 specimens are known for all five species of *Euparixia* and the immature forms are completely unknown. Most of the specimens represent *E. duncani* and were collected at electric lights. Three of the species (*E. formica* Hinton, *E. bruneri* Chapin, and *E. moseri*, new species) have been collected in the nests of leaf-cutting ants of the genus *Atta*. The genera *Euparia*, *Euparixia*, *Euparixoides*, and *Cartwrightia* seem to form a natural group in the Eupariini, all of which are apparently myrmecophilous.

Even though *Euparixia duncani* is represented by the greatest number of specimens, its host relationships have not been established; however, because of its similarity to the other species in the genus, we would also expect it to occur in the nests of leaf-cutting ants. Most specimens have been collected at Tucson and Globe, Ariz., where no species of *Atta* have been found. Another leaf-cutting ant, *Acromyrmex versicolor* (Pergande), does occur in this area and is the suspected host ant. Creighton (1950, p. 325) stated: "In both structure and habits the ants of the genus *Acromyrmex* show a close relationship to the genus *Atta*."

Presumably the beetles are scavengers and live in close harmony with the ants. Their occurrence at great depths (to 12 feet) would

certainly exclude them as accidental. They have been found in the active fungus gardens and in detritus chambers (pl. 2: fig. 2), which consist of old fungus and debris discarded by the ants. It is rather unlikely that they feed on the fungus grown by the ants (pl. 1: fig. 2) since no other members of the subfamily Aphodiinae are known to have this habit. If they actually fed on the fungus, competing with the ants, it would be likely that they would occasionally be thrown out of the nest. This has not been observed. All of the species except *E. costaricensis* (known from the unique type with incomplete data) and *E. moseri*, new species, have been collected at lights and possess fully developed wings.

The behavior of *Euparixia* within the nests has not been observed, and no evidence is available to determine if they are synechthrans (unwelcome guests), synoeketes (unnoticed or tolerated guests), or symphiles (true guests). The latter classification would seem most likely, but many diligent hours of observation will be necessary to determine the true role of *Euparixia*. Cazier and Statham (1962) and Cazier and Mortenson (1965) have made numerous observations on the myrmecophilous scarab genus *Cremastocheilus* and in at least one case, *C. stathamae* Cazier, the adult beetles were found to be obligatory predators on the ant larvae. We have no evidence for similar habits in *Euparixia*. Moser (pers. comm.) believes that the adult, at least, is tied to the ecology of the fungus garden, since all but one of the specimens have been collected in this niche. The numerous species of inquilines associated with detritus cavities are practically never found in fungus gardens.

Certainly many ecological factors are unique in the complicated and extensive underground passages of these fungus-growing ants. Wheeler (1900, p. 855) postulated that the vast amounts of comminuted and decomposing vegetable matter collected by the ants as a soil or culture medium for their fungus would be a favorable resort for numerous myrmecophiles. Walter, Seaton, and Mathewson (1938) record approximately 50 species of insects and arachnids found within the nests in association with *Atta texana* at San Antonio, Tex. They record two scarabs in the subfamily Cetoniinae but no members of the genus *Euparixia* or the subfamily Aphodiinae. Moser (1963) has found a considerable number of interesting myrmecophiles in his studies of the biology and ecology of this ant in Louisiana (some of these have been described by Sabrosky, 1959; Spangler, 1962; and Chillcott, 1965).

Weber (1958, p. 459) stated that the true culture of fungi is confined to the New World ants of the tribe Attiini, all known species of which are dependent on fungus gardens for food. The genus *Atta* is considered to be the most highly developed in the tribe, in

terms of biology, behavior, and morphology. *Acromyrmex* is considered to be nearest it on a phylogenetic basis. It is possible that species of *Euparixia* or related genera might occur with other ant genera in this tribe, namely *Cyphomyrmex*, *Mycetophylax*, *Mycocepurus*, *Myrmicocrypta*, *Apterostigma*, *Sericomyrmex*, and *Trachymyrmex*. The nests of few species of *Atta* or related genera have been investigated thoroughly for inquilines. Certainly the complex association between ants, fungus gardens, and beetles has taken considerable time to evolve. Weber (1958, p. 460) postulated that the South American tropical forests may have been the original home of the attine ants and their fungi, and that this symbiosis may have become established during a period nearly 50 million years ago. Since most attine ants are presently found in South America, it would be surprising if no eupariine scarabs occupied this niche on that continent.

DISTRIBUTION. (fig. 1).—The distribution records for the few specimens available indicate that the species of *Euparixia* are allopatric. It is highly probable that each species of beetle occurs with only one species of ant, but the distribution probably is much more extensive than presently known. The known distribution of the five species of *Euparixia* is as follows: *E. bruneri* Chapin from Baragua, Camaguey, and Santiago de las Vegas, Cuba; *E. costaricensis* Hinton from an undetermined locality in Costa Rica; *E. formica* Hinton from Tejupilco, Mexico; *E. duncani* Brown from southern Arizona and northwestern Mexico; and *E. moseri*, new species, from southwestern Louisiana.

Borgmeier (1959) lists 14 species of *Atta*, most of which occur in South America but no *Euparixia* have been found there. Smith (1963) summarizes the United States and Mexican distribution of the genus *Atta*. Using the known distribution of the ants (fig. 1), we can postulate the probable distribution of the myrmecophilous *Euparixia*. *E. bruneri* Chapin probably occurs with *A. insularis* Guerin throughout the island of Cuba although it has been found only at two localities. *E. formica* Hinton has been recorded as associated with *A. sexdens* (L.) (Hinton, 1934), which has the greatest range of the species of *Atta*. It has been reported from Panama, Colombia, Ecuador, Bolivia, Venezuela, Guiana, Surinam, Brazil, Paraguay, Argentina, and Uruguay; however, it is not recorded from Mexico and the records of Hinton (1934) for this host probably refer to *A. mexicana* Frederick Smith, which is widely distributed in Mexico and recorded from El Salvador and extreme southern Arizona. *A. cephalotes* (L.) is recorded also from southern Mexico (Vera Cruz, Cordova, and Oaxaca), Central America, Ecuador, Colombia, Venezuela, Peru, Bolivia, Guiana, and Brazil but not within the known

range of *E. formica*. *E. costaricensis* Hinton occurs within the range of *A. cephalotes*, whose range is given above, and *A. colombica* Guerin, which has been recorded from Colombia, Panama, Costa Rica, and Guatemala. *E. moseri*, new species, undoubtedly has a

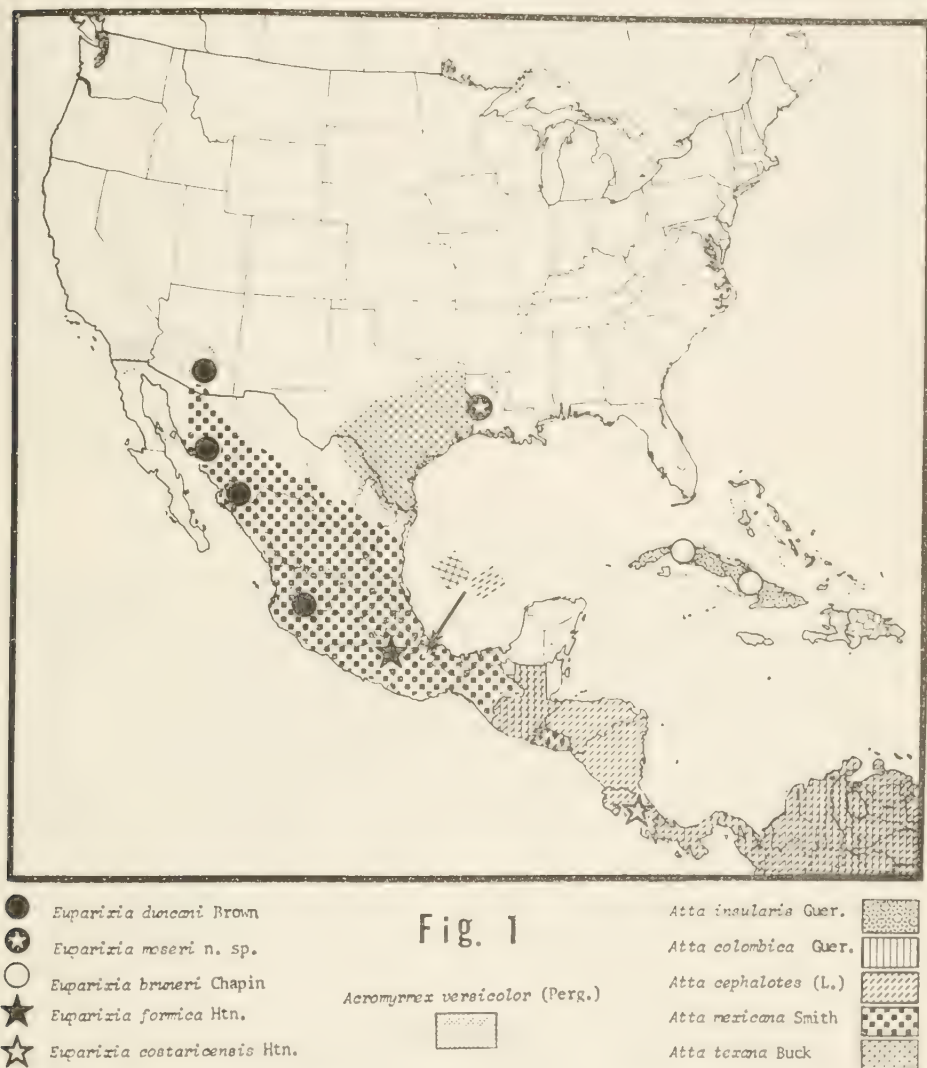


FIGURE 1.—Distribution of the leaf-cutting ants of the genus *Atta* and of the species *Acromyrmex versicolor* Pergande, and the scarab beetles of the genus *Euparixia* in North America. (Drawn by R. E. Woodruff.)

wider range than the few areas now known in southwestern Louisiana, since its host, *A. texana*, occurs over much of the eastern two-thirds of Texas also. Although the host is not established for *E. duncani*, we suspect it is *Acromyrmex versicolor* (Pergande). Creighton (1950)

and Cook (1953) record this ant from southern Arizona, Mojave Desert, and Yucca, Calif., and the type-locality is Calamajuit, Baja California, Mexico. There is a disjunct subspecies, *A. v. chicosensis* (Wheeler), which is recorded from the mountains of the Big Bend area of Texas.

Jones (1917) reported the first record of *A. texana* in Louisiana in 1914, but local residents stated these ants had been there for a long time. Smith (1939) also believed that this species was not introduced recently into Louisiana, but "owing to the fact that it is found largely on non-farming areas or wastelands, it has previously escaped much attention." Smith (1951, p. 832) stated that it had been found in "much of western Louisiana and eastern Texas between the 92d and 101st degrees of longitude but not uniformly distributed in Louisiana at least." The distribution shown on the map (fig. 1) has been derived from Smith (1963) and Moser (in litt.).

A. mexicana has been recorded only recently from the United States (Byars, 1949, and Smith, 1951), in the Organ Pipe National Monument of Arizona about five miles north of the Mexican boundary.

Genus *Euparixia* Brown

This monobasic genus is characterized among the Eupariini by the inflexed clypeal margins, explanate pronotal margins, basally constricted pronotal sides, cariniform elytral intervals (except in *E. costaricensis*), epipleurae covering external tips of middle coxae, middle coxae widely separated, mesosternum expanding laterally to partly cover the anterior half of the middle coxae, the mesosternum separated from the metasternum by a transverse carina, long slender middle and posterior tarsi, and a peculiar arrangement of terminal fimbriae of the posterior tibiae (fig. 9). The terminal outside edge of the tibia is excavated slightly or emarginate opposite the first tarsal segment, with the spurs and one seta on one side of the emargination and a group of three setae on the other side, an arrangement also found in *Euparixoides*.

In general facies and clypeal characters, *Euparixia* is most similar to *Euparixoides*; however, this latter monotypic genus has pronotum laterally and basally, and clypeus anteriorly, noticeably crenate. It has a basally impressed pronotal midline, normally convex elytral intervals, a single terminal spur on middle and posterior tibiae (fig. 12), and middle and hind legs with short, tapering tarsi about half the length of the tibiae. The crenate anterior clypeal margin in *Euparixoides* is unique in the Aphodiinae so far as we know.

Euparixia in many respects is also quite close to *Cartwrightia* even though the latter has more of the appearance of *Ryparus*. *Eu-*

parixia agrees with *Cartwrightia* in the explanate pronotal margin, basally constricted pronotum, epipleurae covering the tips of the widely separated middle coxae, and the mesosternum extending laterally more or less over part of the anterior half of the mesocoxae. In *Cartwrightia*, however, the clypeus is not inflexed at the apex, the margins and surface of the pronotum are very different, and only alternate elytral intervals are carinate. Apically the elytra of *Cartwrightia* are very much as in *Ryparus*. *Cartwrightia* seems to be intermediate between *Euparixia* and *Ryparus*, combining characters from each.

In the explanate pronotal sides *Euparixia* is similar to *Euparia* but *Euparia* lacks the inflexed clypeal apex, the basally constricted pronotum, and cariniform elytral intervals; and in *Euparia* the epipleurae do not cover the anterior tips of mesocoxae; the mesosternum is normally narrow between the coxae and does not extend laterally over the coxae.

Key to Species of Genus *Euparixia* Brown

- 1 Elytral intervals moderately convex, not cariniform; pronotal outline as in figure 7; Costa Rica *costaricensis* Hinton
- 1' Elytral intervals cariniform as in figure 5; pronotal outline not as above; southern Mexico to Louisiana, including Cuba 2
- 2 (1') Pronotum constricted only in posterior one-third, the posterior angles prominent and acute (fig. 2); Arizona and N. Mexico . *duncani* Brown
- 2' (2) Pronotum constricted in posterior one-half or more, the posterior angles evident but rounded (figs. 3-5); distribution not as above 3
- 3 (2') Lateral pronotal margin less explanate, outline as in figure 4, the posterior angles evident; central Mexico *formica* Hinton
- 3' (3) Lateral pronotal margin broadly explanate, outline as in figures 3 and 5, the posterior angles obscured, nearly obliterated; Cuba and Louisiana 4
- 4 (3') Angle of the pronotal constriction more acute (fig. 3); Cuba; host: *Atta insularis* *bruneri* Chapin
- 4' (4) Angle of the pronotal constriction less acute (fig. 5); Louisiana; host: *Atta texana* *moseri* Woodruff and Cartwright

Euparixia moseri Woodruff and Cartwright, new species³

FIGURE 5

Holotype: Length 4.8 mm, width 2.2 mm. Elongate, convex, feebly shining, reddish brown, basal margin of pronotum and legs darker.

Head: Clypeus widely truncate between weak angles, distance between angles greater than length of the feebly arcuate side from

³ This remarkable species is named in honor of Dr. John C. Moser, who is the only person to collect the species and who has discovered many interesting myrmecophiles in his fine work on the biology and ecology of *Atta texana* in Louisiana.

angle to slight genal notch; clypeal margin feebly recurved, apically inflexed ventrally at middle; genae prominent, nearly right angled. Surface finely, quite closely granulate along anterior margin and more widely upward at sides, median tumidity gradually smoother to faint rugulose sculpture over middle and gradually to fine dense punctures upward over frontal area, slightly larger punctures at occipital areas. Frontal suture visible at sides.

Pronotum: Pronotum broader than long (greatest width compared to length measured along center line: width 1.9 mm, length 1.4 mm), very convex. Punctures very coarse and close over basal half, then gradually less coarse and less dense anteriorly, almost impunctate narrowly along anterior margin and over the widely explanate sides anteriorly. Anterior angles broadly rounded. Posterior angles obliterated by constriction and loss of lateral areas over basal two-thirds of pronotum. Pronotum much narrower at base than the width of the elytra between the humeri. Pronotal outline characteristic, differing from other known species (fig. 5).

Elytra: Suboval, widest at apical one-third; intervals strongly carinate, under $\times 50$ magnification the crest of the carina shows minute very close punctures giving a roughened edge; striae deep, punctures fine, deep, and placed at junction of very coarse elliptical or oval depressions that are bordered by a very fine carina. At first glance the striae appear to be simply a chain of very coarse, very close, deep punctures but clean specimens show the fine, deeper punctures between them. Scutellum narrow, about three times as long as wide, smooth with an anterior depression at middle.

Sternum: Prosternum angulate posteriorly at middle. Mesosternum with coxae widely separated basally by slightly more than length of trochanter of middle leg; smooth median depressed area with straight diverging carina-like edge extending three-fourths the distance from sharply delimited base, which is slightly raised above metasternum and ending anteriorly in a wide, shallow depression; laterally, outside depressed median area, flat borders overlap the edges of anterior half of mesocoxae. Mesocoxa smooth basally, finely, closely, setigerously punctate over anterior half between overlapping edges of mesosternum and epipleuron of elytron. Metasternum shallowly depressed medially with moderately deep, complete midline; depression in front of posterior coxae with sharply delimited, arcuate anterior border; laterally metasternum extending far forward between mesocoxae and epipleurae of elytra, bordered here by a finely carinate edge. A few fine to moderate, shallow punctures at base of mesocoxae.

Abdomen: The first three of four visible segments longer at sides than middle, terminal segment longer at middle; all bordered anteriorly

by series of longitudinal carinae enclosing square or rectangular punctures or pits, these rows of depressed squares on first two segments not quite as long as remainder of segment at middle, but rapidly decreasing from lateral fourth to zero at extreme sides; on third segment the depressed squares about as on preceding segments but occupying practically all of the segment at its shortened middle length; terminal segment carinae about two-thirds the segment length at middle; first two segments bordered posteriorly with very close, fine punctures; remaining surface of all segments with scattered fine to medium punctures at middle; very large shallow punctures at sides. Pygidium with roughened eroded area, basally separated by a longitudinal carina.

Legs: Anterior tibia sharply tridentate, middle tooth nearer the basal one than to the apical one. Apical tooth broad, bent outward at nearly a right angle to tibia. Apical spur elongate, narrow, gently curved toward outer tibial margin, flattened, concave beneath, slightly longer than combined length of first three tarsal segments. Single row of about seven short setae on outer tibial margin between base and basal tooth, and one seta on each side of each tooth, with a few scattered setae beneath. Length ratio of tarsal segments: 2-1-1-1-2; claws simple. Anterior femur broad, with perimarginal groove; surface with close moderate punctures bearing extremely short, fine, almost invisible setae; three coarse setae on anterior edge beginning at trochanter and extending one-fourth the femur length. Trochanter exceptionally large, slightly longer than width of femur, finely margined, surface very finely alutaceous. Middle femur long, slender, slightly arcuate, complete posterior marginal groove, surface with moderately close, fine punctures set with extremely short setae; tibia straight, very weakly gradually expanded to twice basal width (fig. 9); terminal ventral edge excavated opposite tarsus with one seta next to spur and three beyond the emargination; first tarsal segment equal to combined length of next three, terminal segment slightly longer than second; claws simple. Posterior leg similar to middle except that the posterior femoral groove extends only half the distance from knee to base.

Diagnosis: Differs from known species in the shape of the pronotal outline (fig. 5), but similar to *E. bruneri* Chapin. Aside from its distribution and host ant, it can be distinguished from *bruneri* by the less acute angle in the middle of the constricted side margin and less angulate posterior of the explanate margin. It is somewhat similar to *E. formica* Hinton but differs by possessing impunctate meso- and metasternum and in the shape of the pronotal outline.

Specimens examined: Total 7. Holotype: Melder, Louisiana, 11 April 1961, J. C. Moser, 2 feet deep in nest of *Atta texana* [USNM No. 68930]. Paratypes:

3 same data as holotype [USNM]; 1-I^{nt}. [International] Paper Company Excav. [Excavation], T1N, R3W, S11, La., John C. Moser, in nest of *Atta texana*, excav. 3/24/60, 12 feet, F. G. [fungus garden] [USNM]; 1-I^{nt}. Paper Co. Excav., T2N, R3W, S10, La., John C. Moser, in nest *Atta texana*, March 25, 1960, central cavity, in fungus garden [USNM]; 1-near Flatwoods, La., T4N, R4W, S30, nest *Atta texana*, 30, Dec. 1958, J. Moser, 5 ft. detritus cavity (Woodruff).

Host: (See under "Biology and Ecology" and "Distribution".) Known only from nests of *Atta texana* (Buckley) in Louisiana. The distribution of this ant is shown on the map (fig. 1).

Euparixia duncani Brown

FIGURE 6

Euparixia duncani Brown 1927, pp. 288-289. [Type: Globe, Ariz.; Canadian National Collection.]

Length 5.0 to 5.75 mm, width 2.0 to 2.4 mm. Elongate, convex, feebly shining (often encrusted with light-colored dirt), reddish brown, darker at clypeal and posterior pronotal margin. Legs and venter similarly colored but slightly darker than dorsum. Pronotum constricted basally at sides with anterolateral margin explanate.

Head: Clypeus truncate across middle one-third, sides feebly curving to prominent genal lobes. Eyes not visible when head is in repose. Clypeal apex inflexed ventrally at middle. Head finely, densely punctured on basal one-third, gradually diminishing to slightly granulate at middle and evenly, finely granulate on anterior one-third.

Pronotum: Broader than long, convex. Punctuation like pits at base but becoming less coarse and less dense toward anterior band. Lateral explanate portion nearly impunctate. Sides explanate on anterior two-thirds; posterior angle obliterated, but the one at constriction acute (nearly 90°). Pronotum much narrower at base than the elytra. Pronotal outline as in figure 2.

Elytra: Together suboval, widest at apical one-third; intervals acutely carinate, striae deep, punctate. The lateral cariniform margin forms a "tooth" on each side in front of humeri. Punctures complicated, but appearing quadrate on disc, gradually becoming less distinct toward sides. Carinate intervals with single row of regularly spaced, very minute, short setae in center. Scutellum elongate, depressed basally at middle.

Sternum: Prosternum weakly angulate posteriorly at middle. Mesosternum with coxae widely separated basally by more than length of trochanter of middle leg; median area smooth but alutaceous, bordered laterally by a raised, flattened, smooth, diverging, slightly arcuate border that quickly widens from a fine carina at base of the coxa to the wide flat edge overlapping the coxal edge from basal

fourth to the epipleuron of the elytron; median area slightly more depressed anteriorly and roughened by close, fine to moderate punctures. Mesosternum and metasternum separated by a fine transverse carina that sometimes has a median longitudinal carina extending a short distance anteriorly and posteriorly. The latter carina gives way quickly to a long, coarse, deep, median line or sulcus. The bordering carina around posterior end of middle coxa becomes very noticeably heavier and separated from disc of metasternum by a coarse deep punctate sulcus; remainder of disc alutaceous and with fine to moderate, close punctures outward from midline; depressed area in front of posterior coxae alutaceous, the arcuate anterior margin deep and sharply bordered; sides scabrous outward and forward between coxa and epipleuron.

Abdomen: Each abdominal sternite depressed on anterior one-half; this depression with longitudinal ridges irregularly spaced. The posterior one-half of each sternite coarsely, irregularly punctate. Pygidium nearly concealed, a transverse depression paralleling the apical border and a longitudinal depression in middle, reaching to transverse depression.

Legs: Anterior tibiae tridentate; apical tooth broad, bent outward at nearly right angle to tibia. Apical spur elongate, narrow, slightly longer than combined length of first three tarsal segments. Anterior trochanter large, prominent, impunctate, rugose ventrally. Anterior femoral groove and about one-half the dorsal surface of femur covered with fine, short, golden setae. Posterior femur with marginal groove covering one-half the length from the apex. Terminal spurs of middle and posterior tibiae unequal: the longer one is four-fifths the length of the first tarsal segment; shorter spur two-thirds the length of the longer one. Middle and posterior tibiae nearly straight, narrow, slightly curving outward toward the weakly expanded apex. First segment of middle and posterior tarsi equal in length to next three segments combined.

Diagnosis: This species, the type of the genus, differs from all known species in the shape of the pronotal outline (fig. 2). The basal constriction is less extensive, creating a broader explanate margin than in any other species. The angle formed at the constriction more acute. It differs further in its distribution and, although its host ant is not known, probably differs in this respect also. It is the most common species in collections and with *E. moseri*, new species, comprises the only two species in the United States.

Specimens examined: Forty-one from the following localities: ARIZONA: 1-Globe, 20-VII-33, F. H. Parker, Lot 3, from O. Bryant Colln., Topotype [CAS]; 2-Globe, VIII, Duncan and Parker, R. Hopping Colln. [CAS]; 1-Globe, VIII, Duncan and Parker [UK]; 1-Globe, 15-VII-27, Duncan and Parker,

O. L. Cartwright Colln. [USNM]; 1-Globe, VIII, Duncan and Parker, O. L. Cartwright Colln. [USNM]; 1-Globe, 24-VIII-52, F. H. Parker, O. L. Cartwright Colln. [USNM]; 1-Tucson, 5-VIII-35, Bryant, 20, Van Dyke Colln. [CAS]; 1-Tucson, 16-VIII-35, R. H. Beamer, coll. at light, L. W. Saylor [CAS]; 8-Tucson, 16-VIII-35, R. H. Beamer, coll. at light [UK]; 2-Tucson, 5-VIII-35, Bryant 20 [INHS]; 1-Tucson, 10-VII-59, K. Radford, blacklight trap [UA]; 1-Tucson, 2-VIII-13, Shive [USNM]; 1-Tucson, 16-VIII-35, R. H. Beamer, M. Robinson Colln. [USNM]; 1-Tucson, 30-VIII-13, J. Shive, Liebeck Colln. [MCZ]; 2-Tucson 1-VIII-13, J. Shive [MCZ]; 1-Tucson, 5-VIII-35, Bryant, C. A. Frost Colln. [MCZ]; 1-Tucson, 10-VIII-59, K. Radford, u.v. lt. trap [UA]; 2-Wickenburg, 20-VIII-38, D. J. and J. N. Knull [OSU]; 1-Wickenburg, 20-VIII-38, D. J. and J. N. Knull, M. Robinson Colln. [USNM]; 1-Douglas, X-1963, J. H. Russell, blacklight [USNM]; 1-Douglas, summer 1964, J. H. Russell, blacklight [USNM]; 1-Palmerlee, Huachuca Mtns. [AMNH]; 1-Hope, Yuma Co., 12-VIII-48, greasewood desert, 1400 feet, at light, F. Werner and W. Nutting [UA]; 1-Sabino Canyon, Catalina Mtns., Pima Co., 26-VII-55, F. G. Werner and G. D. Butler [UA]; 1-Palo Alto, 29-30-VII-16, Mark Robinson Colln. [USNM]. MEXICO: 1-San Bernardo, Rio Mayo, L. W. Saylor Colln. [CAS]; 1-Durango, "enter identification Care No. 1830, Bufo [X]," L. W. Saylor Colln. [CAS]; 1-Acatlan, Puebla, 7-V-57, cerca luz, Wm. W. Gibson [INIA]; 1-Venodio, Sin., 17-V-18, J. A. Kusche [probably Venadillo (Boyle, 1956, and Cantrall, in litt.)]; 1-Tepic, ex Museo H. W. Bates, 1892, Oberthur Colln. [MNHP]; 1-Ajijic, Jalisco, 21-VI-64, W. L. Nutting, 5140 feet [UA]; 1-Ajijic, Jalisco, 16-VII-64, W. L. Nutting, u.v. lt. trap [UA].

Host: The host has not been established for this species even though it is the most abundant in collections. We suspect that it is associated with *Acromyrmex versicolor* and/or *Atta mexicana* although the latter is not known from Tucson or Globe, Ariz., where most of the *E. duncani* have been found. (See also under "Biology and Ecology.")

Euparixia bruneri Chapin

FIGURE 3

Euparixia bruneri Chapin 1940, pp. 40-41. [Type: Baragua, Cuba; U.S. National Museum, No. 53329.]

Length 5.25 mm, width 2.14 mm. Elongate, convex, feebly shining (often encrusted with reddish dirt), reddish brown. Pronotum constricted at side on posterior one-half; sides broadly explanate on anterior one-half.

Head: Clypeus truncate across middle one-third, sides feebly curving to prominent genal lobes. Eyes not visible when head is in repose. Clypeal apex inflexed ventrally at middle. Head finely, densely punctured on basal one-third, gradually diminishing to slightly granulate at middle and evenly, finely granulate on anterior one-third.

Pronotum: Broader than long, very convex. Punctuation like pits at base, becoming less coarse and less dense toward anterior



FIGURES 1, 2.—1, Large nest of *Atta texana* showing mound of excavated subsoil at central area; 2, fungus garden made by *A. texana* (roots often provide support for the gray spongy fungus growing on bits of vegetation supplied by the ants). (Photos courtesy U.S. Forest Service.)



FIGURES 1, 2.—1, Dr. J. C. Moser examining the barrel-sized “central cavity” in a large nest (these cavities are usually 8–12 feet below soil surface); 2, detritus cavities are special holes dug for deposit of exhausted fungus gardens, deceased ants, and other refuse (most species ofinquilines are found here). (Photos courtesy U.S. Forest Service.)

band. Large punctures often confluent, forming narrow ridges between. Lateral explanate portion nearly impunctate. Sides explanate in anterior one-third with anterior angles broadly rounded. Posterior angle barely evident but indicated by definite constriction (this angle more prominent than in *E. moseri*, new species). Pronotum much narrower at base than the elytra. Pronotal outline as in figure 3.

Elytra: Together suboval, widest at apical one-third; intervals acutely carinate, striae deep, punctate. The lateral cariniform margin forms a "tooth" on each side in front of humeri. Punctures complicated, but appearing quadrate on disc, gradually becoming less distinct toward sides. Carinate intervals with single row of regularly spaced, very minute, short setae in center. Scutellum elongate, depressed basally at middle.

Sternum: Mesosternum very similar to that of *E. duncani* except that the alutaceous sculpture of the middle depressed area extends forward only three-fifths of length, the anterior two-fifths is smooth and shining with close moderate punctures, the middle is more distinctly impressed, the anterior one-fifth more or less convex, the anterior border very distinct and the inner edge of the flat diverging lateral margins is noticeably irregular, not so smooth an edge as in *E. duncani*. The metasternum is also similar to *E. duncani* but much smoother with the punctures very fine except for a few coarse close punctures between middle coxae and the arcuate forward edge of the depression in front of the posterior coxae.

Abdomen: Each abdominal sternite depressed on anterior one-half; this depression with longitudinal ridges irregularly punctate. Pygidium nearly concealed, a transverse depression paralleling the apical border and a longitudinal depression in middle, reaching to transverse depression.

Legs: Anterior tibiae tridentate; apical tooth broad, bent outward at nearly right angle to tibia. Apical spur elongate, narrow, slightly longer than combined length of first three tarsal segments. Anterior trochanter large, prominent, impunctate, rugose ventrally. Anterior femoral groove and about one-half the dorsal surface of femur covered with fine, short, golden setae. Posterior femur with marginal groove covering one-half the length from the apex. Terminal spurs of middle and posterior tibiae unequal: the longer one four-fifths the length of the first tarsal segment; shorter spur two-thirds the length of the longer one. Middle and posterior tibiae nearly straight, narrow, slightly curving outward toward the weakly expanded apex. First segment of middle and posterior tarsi equal in length to next three segments combined.

Diagnosis: Differs from all known species in shape of the pronotal outline (fig. 3), but most similar to *E. moseri*, new species, in this respect. It can be separated from this species by the more prominent angle at the middle of the constriction and by the angle of the posterior portion of the explanate sides pointing more outward and making a more acute angle. It also differs in geographic distribution and host ant.

Specimens examined: Total 4; 1—[holotype no. 53329] Cuba, Camaguey, Baragua, V-24-32, at light, Christenson [USNM]; 1—[paratype no. 53329] Cuba, E.E.A. Estacion Experimental Agricola Ento. No. 11,268, Santiago, de las Vegas, Havana, May 2, 1946, Ing. Naranjo, en nido de bibijagua [USNM]; 1—near Havana, Cuba, Fernando de Zayas (Z); 1—[paratype no. 53329] Santiago de las Vegas, Havana, Cuba, July 20/24, det. '36 H. E. Hinton as *Euparixia formica* Hntn. [USNM].

Host: *Atta insularis*, which is known only from Cuba and is most closely related to *Atta texana*.

Euparixia formica Hinton

FIGURE 8

Euparixia formica Hinton 1934, pp. 27-28. [Type: Tejupilco, Mexico; California Academy of Sciences.]

Length 4.65 mm; width 1.95 mm. Elongate, convex, feebly shining, dark reddish brown. Pronotum constricted basally at sides with the anterolateral margin narrowly explanate.

Head: Clypeus truncate across middle one-third, sides feebly curving to prominent genal lobes. Eyes not visible when head is in repose. Clypeal apex inflexed ventrally at middle. Head finely, densely punctured on basal one-third, gradually diminishing to slightly granulate at middle and evenly, finely granulate on anterior one-third.

Pronotum: Broader than long, very convex. Punctuation like dense, coarse pits at base, becoming less coarse and less dense toward anterior band. Lateral explanate portion nearly impunctate. Sides explanate narrowly on anterior two-thirds; posterior angle obliterated, but the one at the constriction rounded, gradually sloping to base. Pronotum much narrower at base than the elytra. Pronotal outline as in figure 4.

Elytra: Together suboval, widest at apical one-third; intervals acutely carinate, striae deep, punctate. The lateral cariniform margin forms a "tooth" on each side in front of humeri. Punctures complicated, but appearing quadrate on disc, gradually becoming less distinct toward sides. Carinate intervals with single row of regularly spaced, very minute, short setae in center. Scutellum elongate, depressed basally at middle.

Sternum: The mesosternum is similar to *E. duncani* and *E. bruneri* but the depressed, median, very finely alutaceous area is sharply outlined and obovate in shape, the edge of the anterior half of this area, as well as the edge of the flattened diverging borders, irregularly cut into by the close, deep, coarse, longitudinally elongate punctures that cover all the anterior part of mesosternum. Metasternum as in *E. duncani* but disc covered with rather close, shallow, moderate punctures and alutaceous sculpture; a few coarse, close punctures between mesocoxae and the arcuate anterior border of the depressed area in front of the posterior coxae; lateral area between mesocoxae and sides strongly bordered by groove of coarse punctures, otherwise a very few punctures and scattered small tubercles.

Abdomen: Each abdominal sternite depressed on anterior one-half, this depression with longitudinal ridges irregularly spaced. The posterior one-half of each sternite coarsely, irregularly punctate. Metasternum with median sulcus moderately impressed, covering entire length; entirely punctate as in the femur (including depression where femur rests). Pygidium nearly concealed, a transverse depression paralleling the apical border and a longitudinal depression in middle reaching to transverse depression.

Legs: Anterior tibiae tridentate; apical tooth broad, bent outward at nearly right angle to tibia. Apical spur elongate, narrow, slightly longer than combined length of first three tarsal segments. Anterior trochanter large, prominent, impunctate, rugose ventrally. Anterior femoral groove and about one-half the dorsal surface of femur covered with fine, short, golden setae. Posterior femur with marginal groove covering one-half the length from the apex. Terminal spurs of middle and posterior tibiae unequal: the longer spur four-fifths the length of the first tarsal segment; shorter spur two-thirds the length of the longer one. Middle and posterior tibiae nearly straight, narrow, slightly curving outward toward the weakly expanded apex. First segment of middle and posterior tarsi equal in length to next three segments combined.

Diagnosis: Small for the genus and darker than usual. Differs from all known species in pronotal outline (fig. 4). The explanate margin is narrower than *E. duncani*, *E. bruneri*, or *E. moseri*. It differs from *E. bruneri* and *E. moseri* in having the metasternum punctate. It differs further from *E. duncani* in the rounded angle at the constriction rather than an acute one. It also differs from all others in distribution and host ant species.

Host: Recorded by Hinton (1934) as being found with *Atta sexdens* at the type-locality, but that species is not now known from Mexico and this record probably refers to *Atta mexicana*. Although this

ant has a wide distribution, as shown in figure 1, *E. formica* is known only from the type-locality in south central Mexico.

Specimens examined: 1—Tejupilco, Mex., Temascaltepec, 23-VI-33, H. E. Hinton and R. L. Usinger, Paratype No. 54675 [USNM].

Euparixia costaricensis Hinton

FIGURE 7

Euparixia costaricensis Hinton 1936, pp. 274-275. [Type: Costa Rica; United States National Museum, No. 54674.]

Holotype: Length 4.5 mm, width 2.2 mm. Elongate, convex, moderately shining, very dark brown with margins of pronotum and head reddish brown. Legs and venter similarly dark brown.

Head: Clypeus widely, shallowly emarginate between small triangular teeth, apex inflexed ventrally at middle; sides very weakly reflexed and weakly arcuate, length from teeth to right-angled, moderately sharply rounded genae equal to that between the teeth. Head moderately convex, weakly rugose in front between teeth, very fine, well-separated punctures, separated by three diameters, over anterior of median convexity and outward toward genae, gradually elongate, larger and closer, to dense, coarse and round across the base. Frontal suture not visible.

Pronotum: Subquadrate; width 1.8 mm, length 1.2 mm. Anterior angles broadly rounded; posterior angles noticeably angulate and rather sharply rounded; base strongly margined, broadly evenly arcuate, the line of curvature continuing forward inside the posterior angles. Lateral margin with a slight but noticeable angle slightly in front of the middle. Surface deeply impressed laterally at anterior third behind the eyes, leaving the anterior angles wide, flat, and explanate, this flattened margin continued narrowly posteriorly to and including the posterior angles; another rather deep, elongate depression paralleling the base, midway between anterior and posterior margins with the ends of this fovea equidistant from the edges of the pronotum and the deeply impressed midline, which diminishes in depth from base to middle; except for the flat anterior angles and lateral margins, which show a few shallow moderate punctures and alutaceous sculpture, the entire surface is strongly and closely punctate, the punctures very coarse in the midline, between, in, and behind the lateral foveae, forward the size gradually smaller with intermixed fine punctures toward the anterior margin, where all are of uniform diameter. A few scattered short, erect setae show in glancing light over the flattened anterior angles.

Elytra: Together elongate oval, convex, widest slightly behind middle. Humeri strongly dentate. Striae strong with deep elongate

punctures separated by less than their length; intervals convex, with very fine, quite close punctures bearing extremely short, fine setae visible in glancing light. Scutellum small, elongate, flat, with two small punctures basally.

Sternum: Coxae of mesosternum widely separated, the distance between them barely more than the length of trochanter of middle leg; mesosternum between the coxae with sharply margined, slightly depressed area shaped like an inverted pear, with a wide, deeply eroded line around the larger forward end of the pear, the median area sloping forward into a wide, deep pit or fovea, the pit sharply margined laterally and anteriorly; this intercoxal area relatively smooth posteriorly and separated from the metasternum by a transverse carina. Metasternum with a more or less pentagonal flat area, with a deep, wide eroded line around each middle coxa, and with a similar, long, deeply eroded midline, this latter separated anteriorly from the coxal lines by a smooth area equalling its own width; the pentagonal area otherwise everywhere with well-separated fine punctures and with three or four coarse punctures immediately behind each mesocoxa; a very large, deeply eroded, anteriorly strongly arcuate area extending almost to sides in front of posterior coxae.

Abdomen: The first three of four visible segments longer at sides than middle, terminal segment slightly longer at middle; last three segments bordered anteriorly by series of longitudinal carinae enclosing square or rectangular punctures or pits, those of the anterior segment uniform from side to side, enclosing square punctures, those at middle of the next twice as long as preceding and gradually much longer at sides, those of the terminal segment long at middle and decreasing in length toward sides; surface of first two visible segments with scattered, very moderate, shallow punctures at middle to coarse at sides. Posterior edge of the segments bordered at middle by a row of close-set smaller punctures that become very close, deep, and very coarse at extreme sides, this area appearing undercut by the punctures; third visible segment smooth except for two or three punctures at extreme sides; terminal segment and most of pygidium apparently eaten on one side by a dermestid but remainder of segment with scattered moderate punctures.

Legs: Anterior tibiae normal, sharply tridentate, the middle tooth slightly nearer apical tooth, the basal tooth equidistant from base to tip of apical tooth. Spur slender, acuminate, not as long as first tooth. Tarsi missing from all legs of the unique holotype. Anterior femur with perimarginal groove; surface with close, shallow, moderate punctures bearing extremely short, fine, almost invisible setae. Trochanter moderately large, ventrally concave. Middle and hind

tibiae slender, only very slightly bowed. Spurs and tarsi missing. Middle and hind femora slightly arcuate, surface with punctures separated by about three diameters of the fine punctures near base and posterior margin, gradually larger along anterior margin and outward to apex, where they are coarse and slightly closer together, usually showing extremely short setae except for two or three longer setae at knee. Middle femur with complete posterior marginal line; hind femur with line inward from knee less than half femoral length.

Diagnosis: Differs from other species of *Euparixia* in the pronotal outline, simply convex elytral intervals, and by the peculiar pear-shaped depression of the mesosternum.

Specimens examined: Unique holotype. Only data: Costa Rica (USNM).

Host: Unknown, but probably *Atta colombica* Guer. or *A. cephalotes* (L.).

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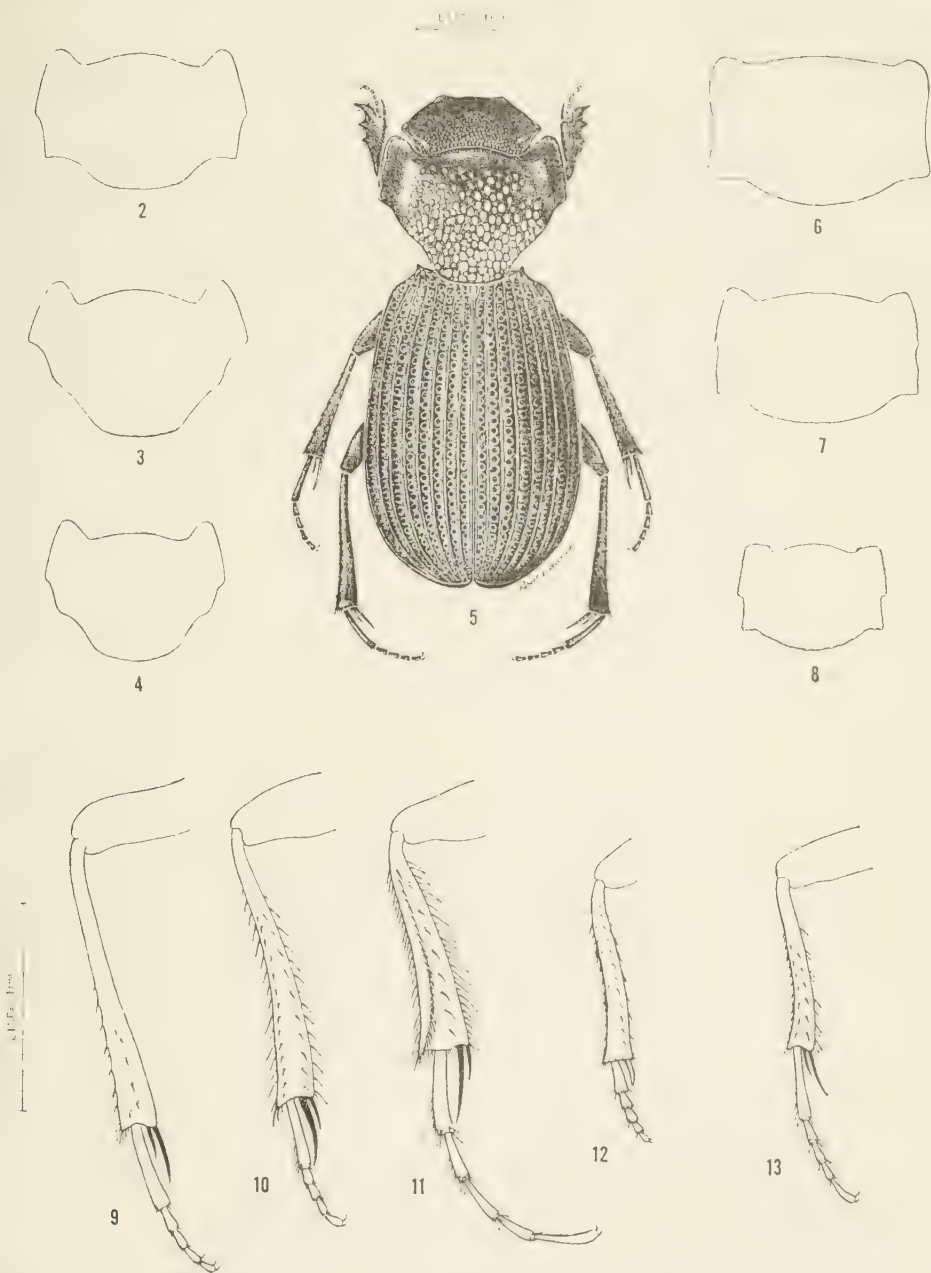
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FIGURES 2-13.—Pronotal outline: 2, *Euparixia duncani* Brown; 3, *Euparixia bruneri* Chapin; 4, *Euparixia formica* Hinton; 6, *Euparia castanea* Serville; 7, *Euparixia costaricensis* Hinton; 8, *Euparixoides cribratus* Hinton. Holotype: 5, *Euparixia moseri*, new species. Posterior tibia and tarsus: 9, *Euparixia moseri*, new species; 10, *Euparia castanea* Serville; 11, *Pseudataenius socialis* (Horn); 12, *Euparixoides cribratus* Hinton; 13, *Cartwrightia intertribalis* Islas. (Drawn by R. E. Woodruff.)

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3617

BREDIN-ARCHBOLD-SMITHSONIAN BIOLOGICAL SURVEY OF DOMINICA

4. Two New Species of *Tiphia* from the West Indies (Hymenoptera: Tphiidae) ¹

By HARRY W. ALLEN ²

The two wasps described below were collected recently on Dominica by Dr. H. E. Evans of the Harvard University Museum of Comparative Zoology and by Dr. W. W. Wirth of the U.S. Department of Agriculture as participants of the survey of that island by the Smithsonian Institution.

Tiphia dominicae, new species

FIGURE 1

This species differs from species of the North American mainland in having the second sternum perceptibly keeled. From other West

¹ Other faunal studies in this series are: 1, Kier, Proc. U.S. Nat. Mus., 1966, vol. 121, no. 3577, pp. 1-9; 2, Stone, *ibid.*, 1966, vol. 121, no. 3578, pp. 1-6; 3, Kirstener, *ibid.*, 1967, vol. 123, no. 3610, pp. 1-6. A companion series on the flora appears in the "Contributions of the United States National Herbarium."

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Indian species that have been described the male may be distinguished by the sparse hairiness and narrowness of the cheek, and the relative shortness of the posterior section of the second cubital cell.

MALE.—Front with primary punctures ranging from contiguous above base of antennae to third-degree density in area lateral to ocelli; numerous minute punctures on lower half extending on sides into upper half. Antenna long and slender. Cheek (fig. 1A) much narrower than diameter of an antennal fossa; sparsely hairy. Clypeal extension usually bidentate. Mandible frequently with a small preapical cusp. Head width 2.72 least distance between eyes (four measured were 2.9, 2.65, 2.6, 2.75).

Dorsum of pronotum with high, sharp transverse carina; punctures small, evenly distributed, of third-degree density. Lateral pronotum with a low, rounded anterior process; disc flat, microscopically aciculate, without groove across its middle. Mesopleuron not any-

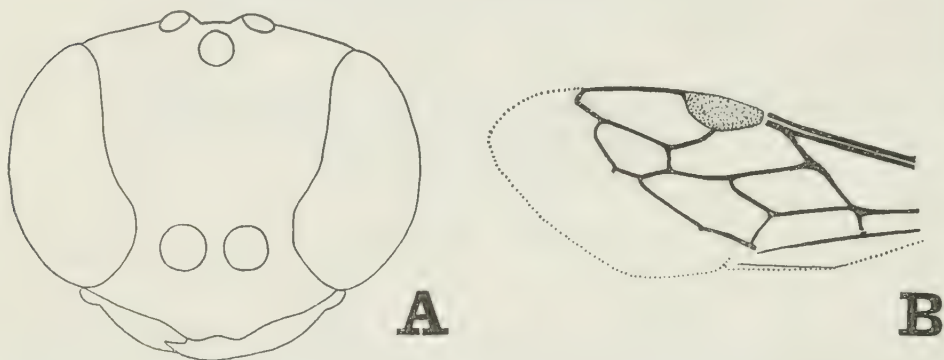


FIGURE 1.—*Tiphia dominicae*, new species: A, outline of head; B, forewing.

where masked under fine appressed hairs; primary punctures small, usually separated by several times their average diameter; minute punctures more numerous than primaries only on upper half and along posterior slope. Hind tibia on inside with a naked longitudinal streak that is moderately ridged on apical half; sensorium obscure. Tegula black, opaque, glossy, without marginal groove. Forewing (fig. 1B) strongly infumated; stigma nearly twice as long as wide; radial cell greatly exceeds second cubital cell in lateral extension; second cubital cell with its anterior section much longer than the posterior (average of four defined in ratios of the first intercubital, listed clockwise: 1.0, 2.5, 1.85, 1.9).

Dorsum of propodeum smooth, polished; areola with slightly concave sides and broadly truncate apex, twice as long as apical width or slightly less. Tergum 1 without a transverse carina, or at most with an irregular poorly developed one in center of segment; preapical

band of fine, discrete punctures in a moderate depression, and at middle about two punctures wide. Intermediate terga glossy; hairs short and sparse; punctures variable but usually very small and widely separated; without apical rows of microscopic punctures or gouges. Sternum 2 with a perceptible median callosity or keel.

Length 6 to 9 mm.

FEMALE.—Unknown.

HOLOTYPE.—♂; Dleau Gommier, Dominica, 1400 ft.; 16-II-65, H. E. Evans; U.S. National Museum.

PARATYPES.—Collected by H. E. Evans on Dominica in 1965: Dleau Gommier, 1400 ft.; 10 ♂♂ on 15-II and 6 ♂♂ on 2-III. Two miles south of mouth, Layou River; 4 ♂♂ on 13-II and 6 ♂♂ on 5-III. Pond Figures R., 400 ft.; 4 ♂♂ on 9-II and 1 ♂ on 9-III. South of Chiltern, 1600 ft.; 4 ♂♂ on 19-II. Freshwater L., 2500 ft.; 3 ♂♂ on 6-III. Roseau; 1 ♂ on 8-III. Clarke Hall, Layou Vall.; 1 ♂ on 10/17-II.

Collected by W. W. Wirth in 1965: d'Leau Gommier; 1 ♂ on 16-III. South of Chiltern Est.; 2 ♂♂ on 2-II. South of Chiltern Est.; 1 ♂ on 20-II.

Tiphia layouae, new species

Tiphia layouae differs from *T. dominica* in having a distinctly wider cheek and a well-defined transverse carina, complete across the dorsum of the first tergum.

MALE.—Differs from the description of the male of *T. dominica* as follows: The secondary punctures of the front are usually confined to a smaller area. The cheek is wider and almost as wide as the antennal fossa. The head width is 2.25 times the least distance between the eyes (four measured were 2.3, 2.3, 2.2, 2.2). The discal punctures of the mesopleuron average slightly coarser. The sections of the second cubital cell defined in ratios of the first intercubital vein and listed clockwise (average of 4) are 1.0, 2.44, 1.76, 1.89 and are almost identical with the cubital cell ratios of *T. dominica*. Tergum 1 with a well-defined transverse carina extending entirely across dorsum.

Length 5 to 8 mm.

FEMALE.—Unknown.

HOLOTYPE.—♂; Clarke Hall, Layou Valley, Dominica; 10/17-II-65, H. E. Evans; U.S. National Museum.

PARATYPES.—Collected by H. E. Evans on Dominica in 1965: Clarke Hall, Layou Valley; 2 ♂♂ on 10/17-II, 2 ♂♂ on 20/28-II, 2 ♂♂ on 3/13-III. Pond Figures R., 400 ft.; 3 ♂♂ on 9-II.

Collected by W. W. Wirth in 1965: Pond Figures R.; 1 ♂ on 25-I. Hillsborough Est.; 1 ♂ on 15-III. Clarke Hall, "malaise trap"; 1 ♂ on 8/10-I. 12 ♂♂; Clarke Hall, "malaise trap"; 12 ♂♂ on

21/31-III. Clarke Hall, "malaise trap"; 5 ♂♂ on 11/20-II. Clarke Hall; 1 ♂ on 1/10-III.

Collected by P. J. Spangler in 1964: Clarke Hall; 1 ♂ on 12/17-XI. South Chiltern; 2 ♂♂ on 8/12-XII.

Collected by G. Steyskal in 1966: Clarke Hall Est.; 1 ♂ on 11-V

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3618

Notes on the *demanii* Section Of Genus *Gonodactylus* Berthold With Descriptions of Three New Species (Crustacea: Stomatopoda)

By Raymond B. Manning
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Among the Indo-West Pacific species assigned to the genus *Gonodactylus* by Kemp (1913) was *G. demanii* Henderson, with two varietal forms, *G. d. spinosus* Bigelow and *G. d. espinosus* Borradaile. These three forms, characterized chiefly by their small size and small ocular scales, and, in the first two, by the strongly arched median carina of the telson and the presence of dorsal spinules on the telson, occupy an isolated position in the genus. Some authors, prior to Kemp's work, considered these forms to be varieties of *G. chiragra* (Fabricius, 1781); subsequent to 1913 they have been considered as distinct species or as three subspecies of *G. demanii*.

As noted above, very small size, with total length not exceeding 50 mm (in some species 30 mm or less), is characteristic of *G. demanii* and its allies. Kemp was certainly aware of this but apparently disregarded it in his attempt to order the apparent variants of the common *G. chiragra*. Earlier workers, notably Lanchester (1903), had recognized numerous lettered or named varieties of *G. chiragra*.

Lanchester attempted to arrange these in transitional sequences leading to a typical form; several of his transitional forms were based on small specimens (*G. c.* var. *incipiens*, *G. c.* var. *segregatus*) with obviously adult features of telson morphology. Kemp noted that small specimens varied more than adults and proposed (1913, p. 151) three hypotheses to explain observed variation in Indo-West Pacific species of the genus: (1) small specimens exhibiting wide variation die before reaching maturity; (2) small specimens represent dwarf races capable of "breeding and perpetuating their precise type"; (3) with growth, small specimens lose their characteristic features and assume the typical facies. Kemp suggested that the second hypothesis was improbable and that most likely variation could be explained by growth changes.

More recently, students of the group have begun to accept the possibility that species might mature at different sizes. Bigelow (1931) suggested some support for this hypothesis, and Serène (1954) recognized two dwarf races ("race naine") from Viet Nam: *G. chiragra* var. *viridis* and *G. falcatus* var. *ternatensis* de Man, 1902. In the western Atlantic, Manning (1967) reported on small species of *Gonodactylus* that had adult features at TL 20 mm and that could be distinguished with no difficulty from the larger species.

The current study shows that in addition to *G. demanii* there are six recognizable species of small size in the Indo-West Pacific, and a survey of the literature indicates that several more may have been recognized in the past by other authors. These include *G. chiragra* var. *affinis* de Man, 1902, and *G. c.* var. *confinis* de Man, 1902, both from Ternate, Indonesia, and *G. c.* var. *segregatus* Lanchester, 1903, from the Maldive and Laccadive Islands. *Gonodactylus affinis* and *G. segregatus* are, from their accounts, very similar, and *G. confinis* may prove to be conspecific with *G. incipiens*, recognized below.

One of the features characteristic of *G. demanii*, sensu stricto, and *G. hendersoni*, new species, described herein, is the absence of setae on the inner edges of the uropodal exopod and endopod; *G. demanii* may have a few proximal setae on the inner margin of the endopod, but most of the inner margin is bare and smooth. In this feature these two species resemble two other species currently placed in *Mesacturus* Miers (= *Gonodactylus* Group II of Kemp, 1913), *M. drepanophorus* (de Man, 1902) and *M. herdmanni* (Tattersall, 1906). The telson morphology of these two pairs of species also seems to be similar, but the two species placed in *Mesacturus* differ in having a sharply trispinous rostral plate. Further study may show that both *M. drepanophorus* and *M. herdmanni* should be reassigned to *Gonodactylus*, for neither have the strongly recurved spines on the uropodal exopod characteristic of the other species of *Mesacturus*.

Gonodactylus demani var. *prucotae* Gravier, 1930, from New Caledonia, has been shown by Serène (1952) to be a synonym of *Mesacturus spinosocarinatus* (Fukuda, 1909). It need not be discussed further here.

This study indicates that the Indo-West Pacific species of *Gonodactylus* are not distributed necessarily throughout the area. *Gonodactylus espinosus* is apparently a Pacific species that does not occur in the Indian Ocean; *G. incipiens* may also occur only in the Pacific although it has been recorded in the Indian Ocean. *Gonodactylus hendersoni* has a wider distribution pattern, between Hawaii and Burma, but it has not been recorded from the western Indian Ocean. Four of the species discussed herein, including *G. demanii*, *G. spinosus* and two new species, are known to occur only in the western Indian Ocean and Red Sea.

Analysis of certain Indo-West Pacific species of *Gonodactylus* as well as work on the American species leads me to believe that qualitative aspects of telson morphology are very important taxonomic characters in this genus. The overall shape of the telson, the shape and position of the marginal teeth and their carinae, the shape and position of the dorsal carinae, and the presence and size of dorsal spinules or tubercles are all important specific characters. It must be kept in mind that the relative tumidity of the median and anterior submedian carinae may change with age and may differ by sex. Characters of the telson in combination with characters afforded by the ocular scales, the rostral plate, the general shape of the lateral processes of the thoracic somites, and especially in the *demanii* section, the shape and setation of uropods, provide excellent characterizations of the species now known. Color patterns and habitat may also prove to be important.

In the material examined, the number following the number of specimens and sex is total length (TL), measured along the midline from the apex of the rostral plate to the apices of the submedian spines of the telson; all measurements are in millimeters (mm). All specimens are in the U.S. National Museum. The illustrations were prepared by my wife Lilly. The support of this study through the Research Awards Program of the Smithsonian Institution is gratefully acknowledged.

In the following key I have included only the species reported herein. Too little is known of the characteristics of *G. affinis*, *G. confinis*, and *G. segregatus* to include them.

Key to *Gonodactylus demanii* and Allies

1. Inner margin of uropodal endopod largely or completely devoid of setae, margin smooth. 2

- Inner margin of uropodal endopod completely fringed with setae, margin serrate at insertion of setae 3
2. Rostral plate with sharp anterolateral angles; submedian teeth of telson with well-marked ventral carina; inner margin of uropodal endopod completely devoid of setae **hendersoni**, new species, p. 4
- Rostral plate with rounded anterolateral angles; submedian teeth of telson poorly or not carinate; inner margin of uropodal endopod with 1-10 proximal setae **demanii**, p. 8
3. Telson with dorsal spinules or spines 4
- Telson smooth dorsally 5
4. Telson broader than long, dorsal spinules large; lateral marginal teeth prominent **lanchesteri**, new species, p. 11
- Telson as long as broad, dorsal spinules small; lateral marginal teeth obscure **spinosus**, p. 14
5. Proximal segment of uropodal exopod lacking fixed distal spine ventrally; lateral processes of sixth and seventh thoracic somites subequal. **choprai**, new species, p. 16
- Proximal segment of uropodal exopod with fixed distal spine ventrally; lateral process of sixth thoracic somite noticeably larger than that of seventh somite 6
6. Intermediate teeth and denticles well-formed; uropodal setae in one marginal series **incipiens**, p. 18
- Intermediate teeth and denticles poorly formed, apex of teeth appressed to margin of submedians; uropodal setae in several series on margin of endopod **espinosus**, p. 21

***Gonodactylus hendersoni*, new species**

FIGURES 1-2

Gonodactylus new species de Man, 1888, p. 574, pl. 22a (fig. 7).

Gonodactylus demani.—Kemp, 1915, p. 182.—Roxas and Estampador, 1930, p. 121.—Roxas, 1930, p. 18.—Serène, 1953, pp. 506, 507 [listed]; 1954, pp. 6, 10, 83, figs. 13-9, 14.—Stephenson and McNeill, 1955, p. 250.

Gonodactylus chiragra var. *Demanii*.—Hansen, 1926, p. 26.

Gonodactylus demanii.—Holthuis, 1941, p. 282, fig. 8b [part].—Dollfus, 1959, p. 242 [part; discussion].

HOLOTYPE.—1♀, 22.3; Burma; G. E. Gates; USNM 120467.

PARATYPES.—2♀, 22.5-23.3; Waikiki, Oahu Id., Hawaiian Ids.; coral head; R. A. Kinzie, III; USNM 120469. 1♀, 16.5; Naha, Okinawa; *Albatross*; 1906; USNM 120468.

DESCRIPTION.—Basal portion of rostral plate angled anterolaterally, anterior margins straight, almost transverse or sloping anterolaterally.

Ocular scales obscure, low, rounded, possibly fused along midline. Mandibular palp and 5 epipods present.

Lateral processes of sixth and seventh thoracic somites subtruncate, rounded anteriorly and posteriorly, subequal in size.

Sixth abdominal somite with 6 swollen carinae, each with small apical spine.

Telson slightly wider than long, with 3 pairs of marginal teeth, submedians slender, with movable apices; intermediates well formed, slender, apices spiniform; lateral teeth well developed, apices sharp; dorsal surface of telson with spinules or tubercles; median carina



FIGURE 1.—*Gonodactylus hendersoni*, new species, female paratype, TL 23.3, Waikiki: a, last abdominal somite, telson, and uropod; b, submedian teeth of telson, ventral view; c, uropod, ventral view; d, rostral plate.

moderately or very inflated, flanked laterally by 1 or more irregular rows of spines converging posteriorly on spined knob; anterior submedian carinae short, rounded, flanked laterally and posteriorly with large, irregularly placed spines; dorsal carinae of submedian teeth with dorsal patch of large spines; numerous spaced submedian

denticles present; 2 spiniform intermediate denticles present, recessed anteriorly; submedian teeth slender, each with prominent longitudinal carina on ventral surface, carina sharp throughout its length; intermediate teeth with shorter ventral carina.

Basal segment of uropod with at most a faint prominence inside dorsal carina; inner margin of both segments of exopod smooth, nonsetose; endopod with inner margin straight, completely devoid of setae; exopod with fixed distal spine on ventral surface of proximal segment; basal prolongation with spines subequal in length, slender inner spine shorter than outer.

COLOR.—In preservative, posterior third of carapace and midline of sixth thoracic and first abdominal somites with rectangular patch of dark chromatophores; patch on carapace with 2 submedian black spots, those on thoracic and abdominal somites each with 1 median black spot.

SIZE.—Females only examined. TL 16.5–23.3. Other measurements of female holotype, TL 22.3: carapace length 4.4; fifth abdominal somite width 3.4; telson length 2.6, width 3.0.

ETYMOLOGY.—The species is named for J. R. Henderson, the carcinologist who named *G. demanii*.

DISCUSSION.—*G. hendersoni*, new species, can be distinguished from all other species in the genus by the following combination of characters: (1) the rostral plate is angled anterolaterally; (2) the uropodal endopod and inner margin of the exopod are completely devoid of setae; and (3) the submedian and intermediate teeth of the telson are each provided with a sharp ventral carina. *Gonodactylus hendersoni*, new species, most closely resembles *G. demanii* but can always be distinguished from that species by the characters listed above. Holthuis (1941) pointed out some of these differences in specimens of both species from Indo-Malaya and the Red Sea.

The female from Burma differs from the two Hawaiian specimens (fig. 1) in the following features: (1) the anterior margins of the rostral plate slope anteriorly; (2) the telson has fewer spines; (3) the median carina of the telson is more circular but not as high; and (4) the uropodal endopod is noticeably broader. The specimen from Okinawa (fig. 2), although smaller, resembles that from Burma. In other features these specimens agree closely.

DISTRIBUTION.—Indo-West Pacific, from the coast of Burma eastward to Hawaii. Records in the literature: off Savu, Seva, and Ambon anchorage, Indonesia (Hansen, 1926); Pulo Edam, Indonesia (de Man, 1888); Kambang, Koepang, and Tidore, Indonesia (Holthuis, 1941); Green Id., Queensland, Australia (Stephenson and McNeill, 1955); Viet Nam (Serène, 1953, 1954); Puerto Galera, Mindoro, Philippine Ids. (Roxas and Estampador, 1930), and Taytay,

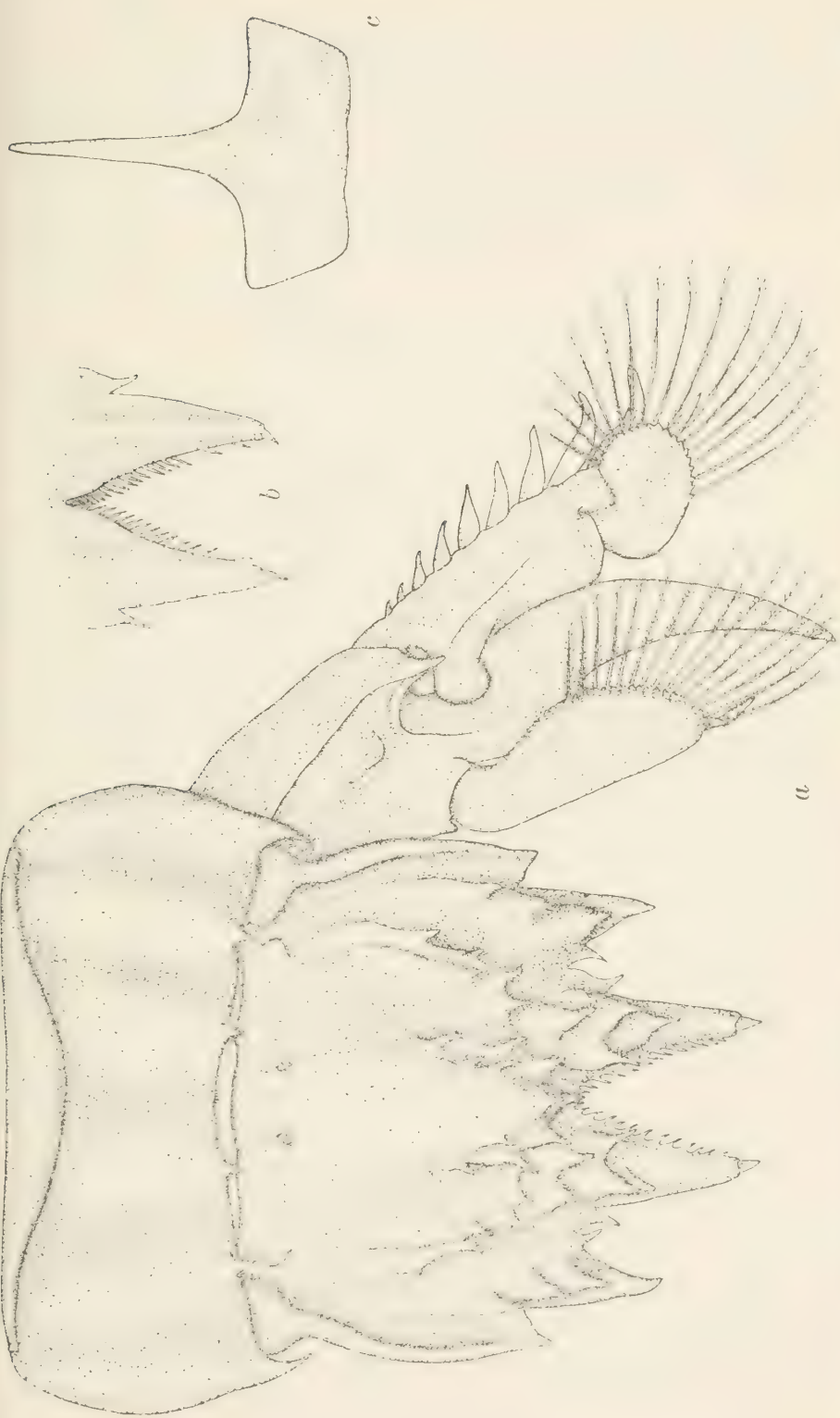


FIGURE 2.—*Gonodactylus hendersoni*, new species, female paratype, TL 16.5, Okinawa: *a*, last abdominal somite and uropod; *b*, submedian teeth of telson, ventral view; *c*, rostral plate.

Palawan Id., Philippine Ids. (Kemp, 1915; Roxas and Estampador, 1930). The habitat and depth range have not been recorded.

In compiling the synonymy of *G. hendersoni*, new species, I have assumed that all records from southern India and the western Indian Ocean should be referred to *G. demanii*.

***Gonodactylus demanii* Henderson, 1893**

FIGURE 3

- Gonodactylus Demanii* Henderson, 1893, p. 455, pl. 40 (figs. 23-24).—Thurston, 1895, p. 120.
Gonodactylus spinosus.—Lenz, 1905, p. 387, pl. 47 (fig. 12).
Gonodactylus Demani.—Nobili, 1905, p. 11.—Parisi, 1940, pp. 4, 6.
Gonodactylus de Mani.—Nobili, 1906, p. 158.
Gonodactylus De Mani.—Nobili, 1906a, p. 330.—Lenz, 1910, p. 572.—Maccagno, 1936, p. 179.—Dollfus, 1938, p. 213, fig. 16.
Gonodactylus demani.—Borradaile, 1907, pp. 210 [key], 212.—Kemp, 1913, pp. 164, 198, pl. 9 (figs. 108-111).—Tattersall, 1921, p. 359.—Kemp and Chopra, 1921, pp. 297, 309.—Gravelly, 1927, p. 151.—Gravier, 1935, p. 360, fig. 3?.—Ramadam, 1936, p. 8.—Taramelli, 1955, pp. 44, 47.
Gonodactylus demanii.—Holthuis, 1941, p. 282, fig. 8a [part].—Stella, 1955, p. 69.—Dollfus, 1959, p. 242 [part; discussion].
Gonodactylus demani demani.—Ingle, 1963, p. 27 [part].

MATERIAL.—1 ♂, 20.9; 1 ♀, 18.6; Dorom Id., Dahlak, Red Sea; A. Ben 'Tuvia; Sta. E57/522; Dec. 27, 1957; exchange from BMNH; USNM 120471. 1 ♂, 23.8; 1 ♀, 30.1; Tor and Ain Musa, Gulf of Suez; R. B. S. Sewell; exchange from BMNH; USNM 120472. 1 ♀, 21.5; western end of Astola Id., ca. 177 mi. west of Karachi, West Pakistan; 0-8 ft., in rocks, sand, scanty, scattered coral; Sta. LW-1; L. P. Woods, et al; IIOE; Nov. 27, 1963; USNM 120473. 1 young ♀, ca. 10.0; ½ mi. northeast of Hare Id., Gulf of Mannar, S. India; from dead coral, 1.5-3 ft.; Sta. GA-64-13a; J. S. Garth; IIOE; Feb. 22, 1964; USNM 120470.

DESCRIPTION.—Basal portion of rostral plate with anterior margins almost transverse; anterolateral angles subacute but rounded.

Ocular scales small, low, rounded or subtruncate.

Lateral processes of sixth and seventh thoracic somites rounded or subtruncate, subequal in size or that of seventh somite slightly larger.

Mandibular palp and 5 epipods present.

Sixth abdominal somite with 6 swollen carinae, each usually armed with apical spinule, spinules obsolete in larger specimens.

Telson broader than long, with 3 pairs of marginal teeth, submedians with movable apices, intermediates and laterals with sharp apices; dorsal surface of telson with spinules; submedian anterior prominences on telson often tuberculate; median carina moderately or very inflated, with 1-3 posterior tubercles; posterolateral margin of median carina

with 0-2 spinules in row converging on anchor; anchor with 1-3 spinules; anterior submedian carinae short, swollen, with apical and postapical spinules and 0-1 lateral and 0-2 dorsal spinules; carinae of submedian teeth with 1-3 dorsal spinules or tubercles; intermediate carinae with 2-3 spinules or tubercles in 1 longitudinal row or 5-6 in 2 rows; numerous small submedian denticles present; 2 sharp intermediate denticles present, recessed anteriorly, inner set on rounded lobe; ventral surface of submedian teeth of telson with low carina on inner side; intermediate teeth lacking ventral carina.

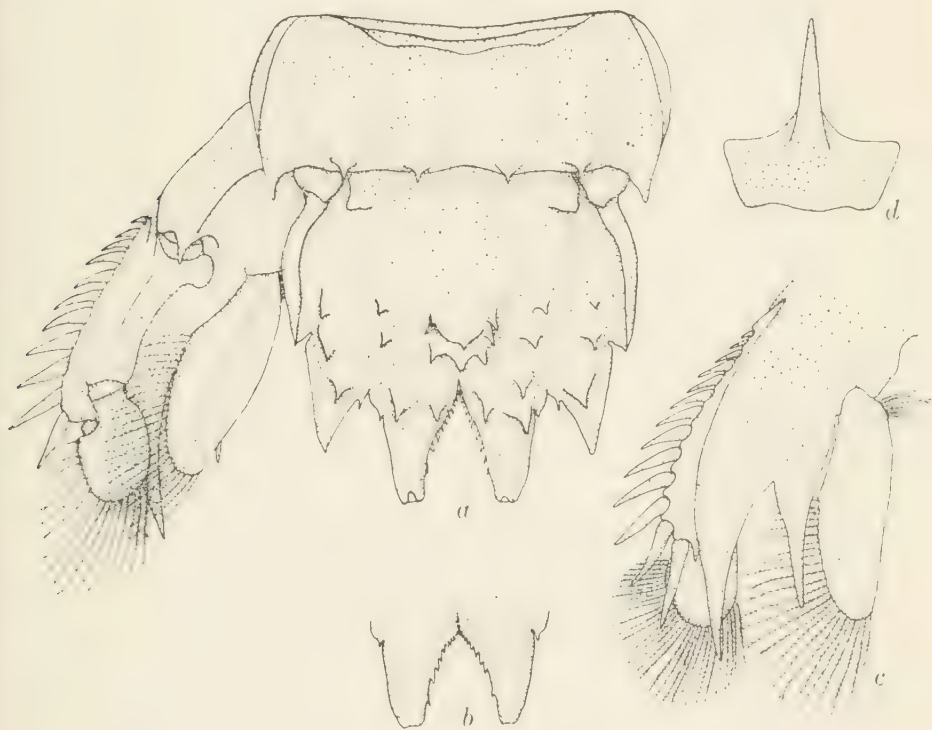


FIGURE 3.—*Gonodactylus demanii* Henderson, female, TL 18.6, Dahlak: *a*, last abdominal somite, telson, and uropod; *b*, submedian teeth of telson, ventral view; *c*, uropod, ventral view; *d*, rostral plate.

Basal segment of uropod without well-marked lobe or projection on dorsal surface inside dorsal carina; proximal segment of exopod nonsetose except for scattered small setae on proximal third; distal segment of exopod with inner margin nonsetose; proximal segment of exopod with fixed distal spine on ventral surface; endopod broad, inner margin convex proximally, concave distally, smooth except for 1-10 proximal plumose setae; apex and outer margin of endopod completely fringed with setae; inner spine of basal prolongation slender, prominent, almost as long as outer spine.

COLOR.—Largely faded in present material; bodies of some specimens show traces of scattered black chromatophores concentrated in dorsal patches on sixth thoracic and first abdominal somites.

SIZE.—Males, TL 20.9–23.8; females, TL ca. 10.0–30.1. Other measurements of male, TL 20.9: carapace length 4.3; fifth abdominal somite width 3.7; telson length 2.5, width 2.9.

DISCUSSION.—*G. demanii* is very similar to *G. hendersoni* in general appearance but differs in having rounded anterolateral angles on the rostral plate, in having a few proximal setae on the inner margin of the uropodal endopod, and in lacking the strong ventral carinae on the submedian and intermediate marginal teeth of the telson.

In general, the carinae of the telson of males are more tumid than those of females, but dorsal tubercles of females are usually sharper.

The number and arrangement of tubercles on the telson are quite variable, but the posterior end of the median carina, the anchor, and the dorsal surface of the other carinae are always armed. The tubercles on the submedian teeth are usually arranged side-by-side, rarely forming a triangle. On the intermediate teeth the tubercles may be arranged in one or two longitudinal rows.

The very small specimen from Hare Id. in the Gulf of Manaar is tentatively assigned here. There are traces of one or two small, proximal setae on the inner margin of the uropodal endopod, the distal segment of the uropodal exopod is more rounded than in the small specimen of *G. hendersoni* from Okinawa, and the ventral carinae on the telson are very poorly developed. Further, the specimen almost completely lacks the dorsal spinules of the telson.

The illustrations of color pattern given by Gravier (1935) were based on an outline drawing of *G. chiragra* (Fabricius).

DISTRIBUTION.—Western Indian Ocean, from localities between India and Mozambique. Records include: Madras Harbor, India (Kemp and Chopra, 1921); Rameswaram, Gulf of Mannar (Henderson, 1893; Thurston, 1895; Ingle, 1963); Paniban and Shingle Id., Gulf of Mannar (Gravely, 1927); Bombay, India (Kemp, 1913); Karachi, West Pakistan (Kemp, 1913); Astola Id., West Pakistan; Persian Gulf (Nobili, 1906; Kemp, 1913); Arabian Sea (Kemp, 1913); from scattered localities in the Red Sea (Nobili, 1906a; Tattersall, 1921; Kemp and Chopra, 1921; Maccagno, 1936; Ramadam, 1936; Parisi, 1940; Holthuis, 1941; Stella, 1955; Ingle, 1963); Zanzibar (Lenz, 1905, 1910; Nobili, 1905; Borradaile, 1907; Taramelli, 1955); Aldabra Id. (Lenz, 1905, 1910); Ibo Archipelago (Kemp, 1913); and from Fort Dauphin (Gravier, 1935) and Maromondia (Dollfus, 1938), Malagasy Republic.

Gonodactylus lanchesteri, new species

FIGURE 4

Gonodactylus spinosus.—Nobili, 1906a, p. 330.

Gonodactylus demani var. *spinosus*.—Tattersall, 1921, p. 361.—Ramadam, 1936, p. 9.—Chopra, 1939, p. 172.

Gonodactylus Demani var. *spinosus*.—Parisi, 1922, pp. 4, 6; 1940, p. 4.

Gonodactylus Demani spinosus.—Gruvel, 1936, p. 177.

Gonodactylus demani spinosus.—Monod, 1937, p. 19.—Ingle, 1963, p. 28, figs. 25, 55.

Gonodactylus De Mani var. *spinosus*.—Dollfus, 1938, p. 215, fig. 17.

?*Gonodactylus demanii*.—Barnard, 1950, p. 862, fig. 3e.

HOLOTYPE.—1 ♂, 34.2; Jungi Bay, Ibo Archipelago, Mozambique; sand, mud, shell; 5–18 fms.; A. Patience; USNM 120286.

PARATYPES.—1 ♂, 22.7; 5 ♀, 22.3–31.5; data as in holotype; USNM 44493.

OTHER MATERIAL.—1 ♂, 17.4; Eylath, Red Sea; Sta. E55/710; H. Steinitz; Nov. 30, 1955; exchange from BMNH; USNM 120288. 1♀, 16.8; Eylath, Red Sea; Sta. E55/735a; H. Steinitz; Nov. 30, 1955; exchange from BMNH; USNM 120287. 4 ♂, 15.6–24.8; Andromache Reef, $\frac{1}{4}$ – $\frac{3}{4}$ mi. offshore from Mombasa, Kenya; 0–1 m, coral reef and tide pools; Taylor, et al., Sta. RS-4; IIOE; Nov. 16, 1964; USNM 120291. 1 ♂, 29.8; 2 ♀, 24.8–25.9; Andromache Reef, south of south channel off Mombasa Id., Mombasa, Kenya; $\frac{1}{3}$ –1 m in reef lagoon; L. S. Kornicker; IIOE; Nov. 15, 1964; USNM 120293. 1 ♂, 19.4; Andromache Reef, off Mombasa, Kenya; reef flat, 0–3.5 ft.; Fehlman, et al., Sta. HA-2; IIOE; Nov. 16, 1964; USNM 120294. 1 ♂, 21.9; southwestern end of Mouniameri Id., between Mayotta and Pamanzi Ids., Comoro Ids.; rocky lava and coral reef; 0–4 m; Taylor, et al., Sta. RS-14; IIOE; Nov. 23, 1964; USNM 120292.

DESCRIPTION.—Basal portion of rostral plate rounded antero-laterally, anterior margins of basal portion transverse or sloping posterolaterally.

Ocular scales low, rounded or subtruncate.

Mandibular palp and 5 epipods present.

Lateral processes of sixth and seventh thoracic somites rounded or subtruncate, subequal in size.

Sixth abdominal somite with 6 swollen carinae, apical spines occasionally absent on larger specimens.

Telson broader than long, with 3 pairs of marginal teeth, submedians with movable apices; intermediate and lateral teeth short, blunt, apices rounded, sharper in smaller specimens; lateral teeth distinct; median carina very inflated in all specimens, in some merging laterally with anterior submedians; dorsal spinulation of telson variable, with scattered spines all over dorsal surface or with smooth

dorsal carinae, spinules or tubercles restricted to carinae of submedian and intermediate teeth; anchor not distinct, fused with median carina; carinae of submedian teeth swollen, with several scattered dorsal tubercles or spinules proximally; carinae of intermediate teeth swollen, with few scattered dorsal tubercles or spinules; numerous small, distinct submedian denticles present; 2 intermediate

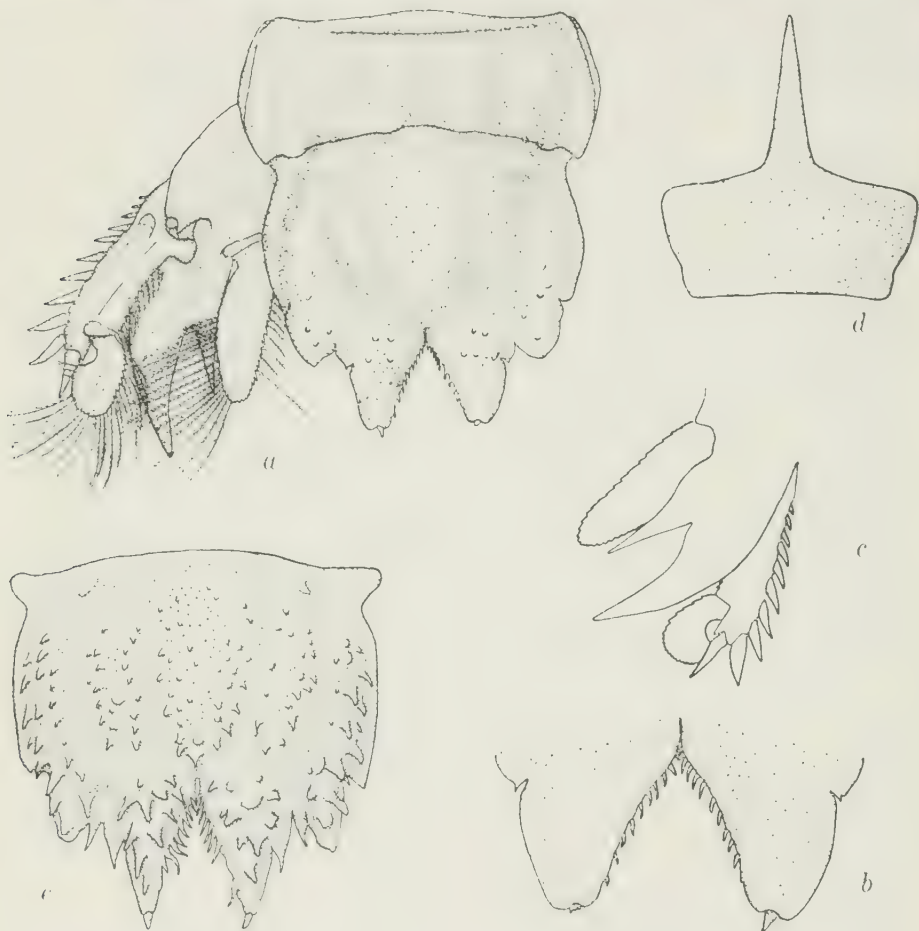


FIGURE 4.—*Gonodactylus lanchesteri*, new species, male holotype, TL 34.2, Junghi Bay: *a*, last abdominal somite, telson, and uropod; *b*, submedian teeth of telson, ventral view; *c*, ventral view of uropod (setae omitted); *d*, rostral plate. Female paratype, TL 22.3, Junghi Bay: *e*, telson.

denticles present, both usually recessed anteriorly, apex of inner occasionally reaching to or beyond apex of teeth; sharp lateral denticle present on some specimens; submedian teeth lacking well-defined ventral carina.

Basal segment of exopod with inconspicuous lobe on dorsal surface inside of dorsal carina; uropodal endopod slender, inner margin

almost straight, completely fringed with setae; both segments of exopod with normal complement of setae; proximal segment of exopod with fixed distal spine on ventral surface; basal prolongation with inner spine slender, shorter than outer.

COLOR.—Several specimens have dark chromatophores scattered over the body, concentrated in dark patches on the sixth thoracic and first abdominal somite, and in transverse bands on the carapace and abdominal somites; sixth thoracic somite with dark lateral patches.

SIZE.—Males, TL 15.6–34.2; females, TL 16.8–31.5. Other measurements of male holotype, TL 34.2: carapace length 7.7; fifth abdominal somite width 6.3; telson length 4.8, width 5.3.

ETYMOLOGY.—The species is named for W. F. Lanchester, the carcinologist from Cambridge who was the first to recognize the importance of the diversity of the structure of the telson in *Gonodactylus*.

DISCUSSION.—*G. lanchesteri* is most similar to *G. spinosus* Bigelow, differing primarily in the telson having well-developed intermediate marginal teeth, being wider than long, and having fewer (and usually larger) dorsal spinules. As in *G. hendersoni*, the number and arrangement of spinules on the telson is very variable. *G. lanchesteri* has no trace of the ventral carinae on the submedian marginal teeth of the telson that are characteristic of *G. demanii* and *G. hendersoni*, and the full complement of setae on the uropod distinguishes both *G. lanchesteri* and *G. spinosus* from *G. demanii* and *G. hendersoni*.

As in other species, the carinae of the telson and sixth abdominal somite in males are more swollen than in females, and younger specimens are more spinulose than adults. The extent of spinule variation on the telson is shown in figure 4.

There may be two species mixed in this series of specimens, both of which have well-developed intermediate marginal teeth on the telson. One of the specimens from Andromache Reef (male, TL 19.4) has many small spinules on the dorsal carinae of the telson, as does the illustrated female from the type-locality. The remainder of the specimens have far fewer spinules on the dorsal carinae of the telson and larger spinules on the carinae of the marginal teeth. I have been unable to find other differences.

DISTRIBUTION.—Western Indian Ocean, from the Red Sea to South Africa. Records in the literature include Red Sea (Nobili, 1906a; Tattersall, 1921; Parisi, 1922; Gruvel, 1936; Ramadam, 1936; Monod, 1937; Dollfus, 1938; Chopra, 1939; Parisi, 1940; Ingle, 1963); Gulf of Aden (Chopra, 1939); Mozambique (Barnard, 1950); and South Africa (Barnard, 1950). On reefs from shallow water to 18 fms.

Gonodactylus spinosus Bigelow, 1893

FIGURE 5

Gonodactylus spinosus Bigelow, 1893, p. 101; 1894, p. 493.—Borradaile, 1907, pp. 210 [key], 212.—Bigelow, 1926, p. 579, figs. 1-2.—Manning, 1962, p. 3. *Gonodactylus chiragra* var. *spinosus*.—Lanchester, 1903, p. 454, pl. 23 (fig. 14). *Gonodactylus demani* var. *spinosus*.—Kemp, 1913, p. 165, pl. 9 (fig. 112).—Kemp and Chopra, 1921, pp. 310, 311.

MATERIAL.—1♀, 21.0; Mauritius; N. B. Pike; lectotype; USNM 64773. 1♀, 20.5; same data; paralectotype; USNM 4295. 1♂, 13.5; 1♀, 18.7; same data; USNM 120309. 1♂, 14.8; between Neptune and Triton Bastions, Galle Forte, Ceylon; from living *Pocillopora*, in 1-3 ft.; J. S. Garth, Sta. GA 64-16c; IIOE; Mar. 5, 1964; USNM 120308.

DESCRIPTION.—Basal portion of rostral plate rounded anterolaterally, anterior margins sloping posteriorly.

Ocular scales small, low.

Mandibular palp and 5 epipods present.

Lateral processes of sixth and seventh thoracic somites rounded, subequal in size.

Sixth abdominal somite with 6 well-defined carinae, submedians sharpest, all with posterior spines.

Telson as long as or longer than broad, with 3 pairs of marginal teeth; submedians thick, with movable apices, intermediates inflated, apices small but sharp, lateral barely discernible but each with small apical tubercle; most of dorsal surface of telson covered with small spinules; median carina elongate, moderately swollen, smooth dorsally, spinulose laterally and posteriorly; anterior submedian carinae elongate, moderately swollen, usually completely covered with small spinules, dorsal surface smooth in some specimens; carinae of submedian teeth swollen spinulose lobes, each as broad as tooth, completely covered with spinules; carinae of intermediate teeth swollen, spinulose dorsally and laterally, lateral spinules obscuring lateral tooth in dorsal view; numerous short submedian denticles present; 2 intermediate denticles present, inner set posterior to outer and to apex of intermediate tooth; lateral denticles present or absent; ventral surface of telson without longitudinal carinae.

Basal segment of uropod with low, rounded lobe on dorsal surface inside dorsal carina; exopod with normal complement of setae, proximal segment with fixed distal spine on ventral surface; endopod broad, margin completely setose; inner spine of basal prolongation slender, shorter than outer.

COLOR.—Faded in all specimens.

SIZE.—Male, TL 13.5-14.8; females, TL 18.7-21.0. Other measurements of female lectotype, TL 21.0: carapace length 4.6; fifth abdominal somite width 3.5; telson length 2.8, width 2.8.

DISCUSSION.—*G. spinosus* most closely resembles *G. lanchesteri*, described above, but differs in having a narrower telson, with poorly developed intermediate marginal teeth, and in having many more, smaller dorsal tubercles on the carinae of the telson. In *G. spinosus* the intermediate denticles are set at or behind the apex of the intermediate tooth, whereas in *G. lanchesteri* they are recessed anteriorly. The basic telson shape in *G. spinosus* is similar to that found in *G.*



FIGURE 5.—*Gonodactylus spinosus* Bigelow, female lectotype, TL 21.0, Mauritius: *a*, last abdominal somite, telson, and uropod; *b*, submedian teeth of telson, ventral view; *c*, uropod, ventral view; *d*, rostral plate.

espinosus (see below), but that species differs in several features, the most important of which is the lack of dorsal spinules on the telson.

The larger of Bigelow's syntypes, a female, TL 21.0, from Mauritius, is here selected as the lectotype; the other syntype, a female, TL 20.5, from the same locality, becomes a paralectotype. Both specimens are in the U.S. National Museum.

DISTRIBUTION.—Western Indian Ocean, where it has been recorded from several localities between the Persian Gulf, Mauritius, and Ceylon. Records in the literature include Pearl Banks, Persian Gulf (Kemp and Chopra, 1921); the Seychelle Ids. (Borradaile, 1907; Manning, 1962); Mauritius (Bigelow, 1893, 1894, 1926); Male Atoll and Goifurfehendu Atoll, Maldive Ids. (Lanchester, 1903); and Ceylon (Kemp, 1913). It may be restricted to shallow water.

I have assumed that records of this species from the Red Sea should be referred to *G. lanchesteri*; all material from the Red Sea examined by me proved to belong to the latter species.

Gonodactylus choprai, new species

FIGURE 6

Gonodactylus demani ? *espinosus*.—Chopra, 1939, p. 176.

Gonodactylus demani espinosus.—Ingle, 1963, p. 28, figs. 26, 56.

HOLOTYPE.—1♀, 20.4; off Somali Republic; 09°36'N, 50°01'E; *Anton Bruun* Sta. 9-444; 78-82 m; Dec. 16, 1964; USNM 120275.

PARATYPES.—6♂, 11.6-16.4; 11♀, 12.2-19.3; data as in holotype; USNM 120277. 4♂, 11.3-15.0; 2♀, 14.8-20.8; off Somali Republic; 09°35'N, 50°59'E; *Anton Bruun* Sta. 9-442; 70-80 m; Dec. 16, 1964; USNM 120276.

DESCRIPTION.—Basal portion of rostral plate with transverse anterior margins, rounded anterolaterally.

Ocular scales small, erect, round.

Mandibular palp and 5 epipods present.

Lateral processes of sixth and seventh thoracic somites rounded, subequal, or process of sixth somite slightly larger.

Carinae of sixth abdominal somite swollen, unarmed posteriorly except for laterals.

Telson broader than long, with 3 pairs of marginal teeth, submedian well developed, with movable apices, intermediates poorly formed, laterals barely discernible, position marked by faint indentation on lateral margin; dorsal surface of telson without spinules; median carina inflated (particularly in larger males), tapering posteriorly, flanked laterally by accessory median carinae that fuse posteriorly with median; in larger specimens accessory medians separated from median by a groove or pit on each side; dorsal submedian carinae swollen, not as broad as median; carinae of submedian and intermediate teeth not markedly inflated; numerous short submedian denticles present; 2 intermediate denticles present, inner set posterior to outer; 1 or 2 small supplementary spinules on lateral margin posterior to apex of intermediate tooth; lateral denticle absent; marginal teeth without longitudinal ventral carinae.

Basal segment of uropod without well-marked lobe or projection on dorsal surface inside dorsal carina; inner margin of proximal segment and all of distal segment of exopod with single row of plumose setae on margin; proximal segment of exopod lacking fixed distal spine on ventral surface; endopod slender, tapering distally, single layer of marginal plumose setae present; inner spine of basal prolongation of uropod much smaller than outer.

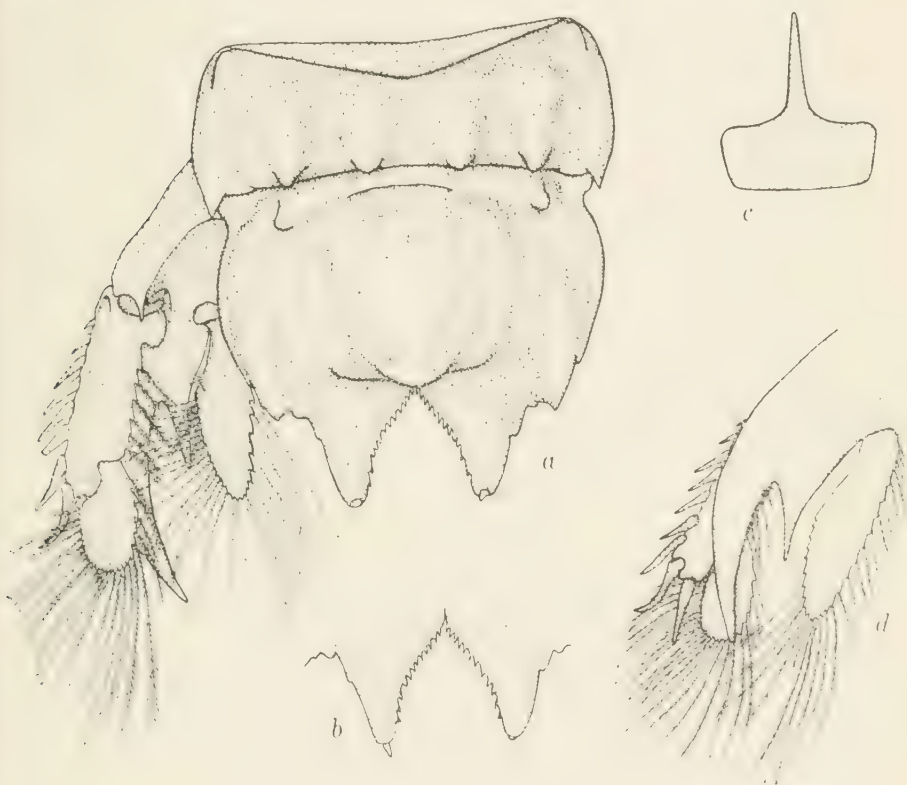


FIGURE 6.—*Gonodactylus choprai*, new species, female holotype, TL 20.4, off Somali Republic: *a*, last abdominal somite, telson, and uropod; *b*, submedian teeth of telson, ventral view; *c*, rostral plate; *d*, uropod, ventral view.

COLOR.—In preservative, body with numerous dark chromatophores scattered over light background; pleura dark, pigment most concentrated on last thoracic and last abdominal somite; posterior third of carapace, sixth thoracic segment, and first, fourth, and sixth abdominal somites with dark dorsal patch of chromatophores, that on first abdominal somite most prominent; males with dark ventral surface, pigmentation of body more intense than in females.

SIZE.—Males, TL 11.3–16.4; females, TL 12.2–20.8. Other measurements of female holotype, TL 20.4: carapace length 4.2; fifth abdominal somite width 3.6; telson length 2.5, width 3.2.

ETYMOLOGY.—This species is named for Bruno Chopra, who was the first to record its occurrence.

DISCUSSION.—*G. choprai*, new species, can be distinguished from all other species of *Gonodactylus* with small ocular scales by the absence of a fixed distal spine on the ventral surface of the proximal segment of the uropodal exopod.

In sculpture and proportion of the telson, *G. choprai*, new species, closely resembles *G. chiragra* var. *segregatus* Lanchester, 1903, from the Maldives and Laccadive Ids., and the two forms may be conspecific. Lanchester's figure shows that *G. c.* var. *segregatus* has all of the carinae of the last abdominal somite provided with posterior spines, whereas these carinae are unarmed in all of the specimens of *G. choprai* seen by me.

Lanchester's specimens apparently came from both shallow reefs and offshore habitats; there is a possibility that his material comprises more than one species.

DISTRIBUTION.—Western Indian Ocean, including off the Somali Republic, the South Arabian coast (Chopra, 1939), and the Red Sea (Chopra, 1939), from moderate depths in 70–82 m. Ingle (1963) reported upon Chopra's material.

***Gonodactylus incipiens* Lanchester, 1903**

FIGURE 7

Gonodactylus chiragra var. *incipiens* a Lanchester, 1903, p. 451, pl. 23 (fig. 10) [not *incipiens* b Lanchester, p. 451].

Gonodactylus chiragra var. *incipiens*.—Tattersall, 1906, p. 167.

Gonodactylus chiragra var. *a incipiens*.—Borradaile, 1907, p. 211 [key].

Not *Gonodactylus chiragra* var. *incipiens*.—Lenz, 1910, p. 571 [= *incipiens* b ??].

?? *Gonodactylus chiragra incipiens*.—Lenz, 1912, p. 4.

Gonodactylus chiragra.—Manning, 1966, p. 113 [part; *G. c.* var. *incipiens* in discussion on p. 114].

MATERIAL.—2♂, 13.4–15.3; 4♀, 15.7–20.0; Ritidian Pt., Guam Id., Marianna Ids.; R. H. Baker; July 12, 1945; USNM 120285. 1♂, 18.8; channel, Hull Id., Phoenix Ids.; killed with TNT; July 7–17, 1939; L. P. Schultz; USNM 120284. 1♀, 13.0; Fakarava Id., Tuamotu Archipelago; Oct. 13, 1899; *Albatross*; USNM 120283. 2♂, 16.6–18.6; 2♀, 21.8–24.2; coral reef at Yirrkala, Arnhem Land, Northern Territory, Australia; Australian Museum-U.S. National Museum Arnhem Land Expedition, Sta. C13–17; Aug. 26, 1948; R. R. Miller; USNM 111367.

DESCRIPTION.—Basal portion of rostral plate with anterior margin sloping posteriorly, rounded anterolaterally.

Ocular scales small, rounded.

Mandibular palp and 5 epipods present.

Lateral processes of sixth and seventh thoracic somites rounded anteriorly and posteriorly; process noticeably larger on sixth somite.

Carinae of sixth abdominal somite swollen, with or without posterior spines.

Telson with length and width subequal, appearing elongate, with 3 pairs of marginal teeth, submedians with movable apices; intermediate teeth well developed, apices angled but not sharp; lateral teeth obscure, apices not projecting much past lateral margin of telson; telson without dorsal spinules or tubercles; median carina very inflated and rounded in males, almost fusing laterally with dorsal submedians, more oval in females, rarely with posterior tubercle; knob not distinct, fused to median carina; carinae of marginal teeth inflated; numerous submedian denticles present; 2 sharp intermediate denticles present, recessed slightly, not projecting posteriorly past apex of intermediate tooth; submedian teeth relatively slender, ventral surface lacking longitudinal carina.

Basal segment of uropod lacking prominent lobe or projection on dorsal surface inside dorsal carina; inner margin of proximal segment and all of distal segment of exopod with single row of setae; proximal segment of exopod with small, fixed spine on distal end of ventral surface; endopod short, broad, completely fringed with setae set in 1 row; inner spine of basal prolongation slender, shorter than outer.

COLOR.—Faded in most of the specimens reported herein. Some of the specimens from Guam show traces of a dark median patch on the sixth thoracic and first and fourth abdominal somites.

SIZE.—Males, TL 13.4–18.8; females, TL 13.0–24.2. Other measurements of male, TL 18.6: carapace length 3.9; fifth abdominal somite width 2.9; telson length 2.5, width 2.6.

DISCUSSION.—It is with some hesitation that I assign these small but obviously mature specimens to Lanchester's species without comparison with his type. The specimens agree well with the illustration of the telson provided by Lanchester, the only major difference being that in males the accessory median carinae may be completely obliterated by the tumid median carina.

In smaller specimens of either sex the accessory median carinae can be distinguished as swollen lobes separated from the posterior end of the median carina by a shallow lateral depression. In only one of the specimens the median carina of the telson is provided with a median, posterior tubercle.

Gonodactylus confinis de Man, 1902, from Ternate, Indonesia, appears to be similar in general telson structure, but, according to de Man's account, that species has a median and two submedian spinules on the end of the swollen median carina. If de Man's

species proves to be conspecific with *G. incipiens*, the older name *G. confinis* will have to be used for the species.

Gonodactylus incipiens resembles *G. choprai* in lacking dorsal spinules on the carinae of the telson, but the former differs in having a small, fixed distal spine on the ventral surface of the proximal segment of the uropodal exopod.

Both *G. incipiens* and *G. espinosus* differ from all other species reported herein in having the lateral process of the sixth thoracic

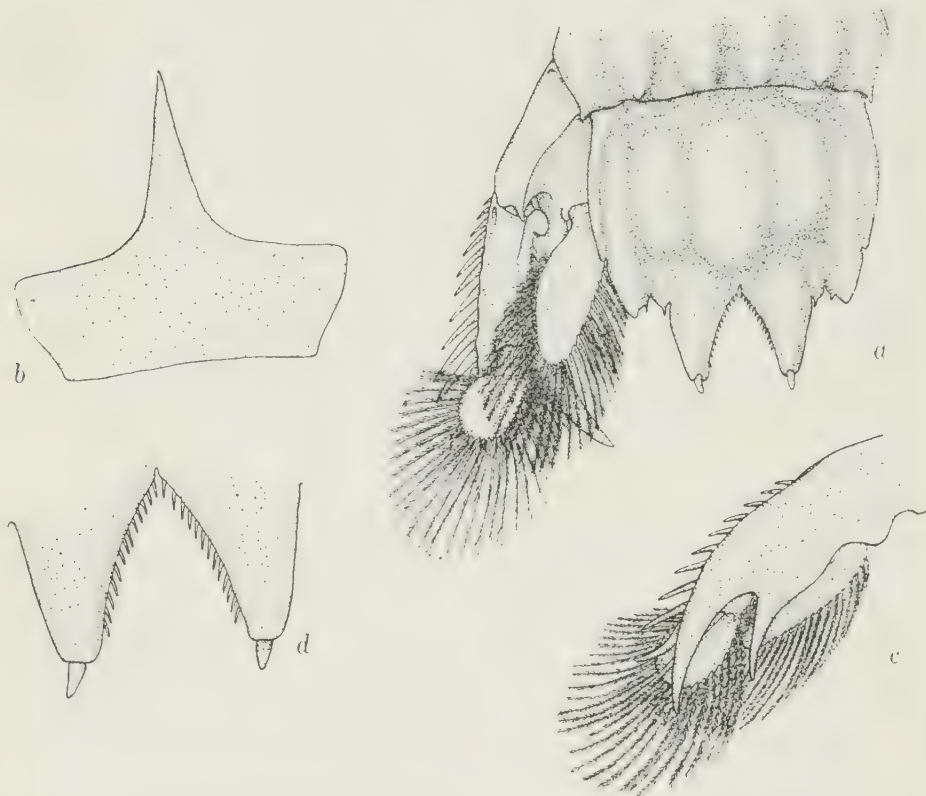


FIGURE 7.—*Gonodactylus incipiens* Lanchester, male, TL 18.8, Hull Island: *a*, last abdominal somite, telson, and uropod; *b*, rostral plate; *c*, uropod, ventral view; *d*, submedian teeth of telson, ventral view.

somite noticeably broader and more truncate than that of the seventh somite; in all the other species the lateral processes are subequal in size.

Lanchester (1903) recognized two forms in his *G. c.* var. *incipiens*: *G. c.* var. *incipiens* a was based on a small female, TL 16.5, from Funafuti, Ellice Ids., and is the form recognized herein as a distinct species; *G. c.* var. *incipiens* b was based on de Man's (1898) figure of a specimen of *G. chiragra*, presumable *G. chiragra*, sensu stricto.

J. G. de Man's specimens, TL 77–98 mm, were from the Celebes. Kemp (1913) considered *G. incipiens* to be identical with *G. chiragra*, but he made no distinction between the lettered forms and their size differences. In order to settle the identity of *G. incipiens*, the female, TL 16.5, reported by Lanchester (1903) from Funafuti, Ellice Ids., is here selected as the lectotype.

The specimens reported by Lenz (1910, 1912) probably belong to *G. chiragra* rather than to the species reported here; all are large specimens.

Manning (1966) noted that four small specimens assigned to *G. chiragra* resembled the varietal form described by Lanchester. Comparison of those four specimens from Australia with the others reported herein leaves no doubt that they are conspecific. Manning also noted that the rostral plate of the Australian specimens resembled that illustrated by Serène (1954) for *G. chiragra* var. *viridis*.

DISTRIBUTION. Indo-West Pacific, with most records from the Pacific Ocean, including Guam; Funafuti Id., Ellice Ids. (Lanchester, 1903); Hull Id., Phoenix Ids., Fakarava Id., Tuamotu Archipelago; and Yirrkala, Northern Australia (Manning, 1966). Tattersall (1906) reported a small specimen from Ceylon; his record is the only one from the Indian Ocean. Habitat and depth range are unrecorded, except for the Australian specimens, which were collected on coral reefs.

***Gonodactylus espinosus* Borradaile, 1898**

FIGURE 8

Gonodactylus espinosus Borradaile, 1898, p. 35, figs. 5a–b, pl. 5; 1907, p. 210 [key].

Gonodactylus chiragra espinosus.—Lanchester, 1903, p. 455.

Gonodactylus demani espinosus.—Kemp, 1913, p. 166.

Gonodactylus chiragra.—Edmondson, 1923, p. 36, fig. 3h [not *G. chiragra* (Fabricius, 1781)].

Not *Gonodactylus demani espinosus*.—Chopra, 1939, p. 176.—Ingle, 1963, p. 28, figs. 26, 56 [= *G. choprai*, new species].

MATERIAL.—1♀, 22.7; washed from lagoon reef corals, Fanning Island, Line Ids.; 03°50' N, 159°20' W; Fanning Id. Expedition Sta. 6; June 30, 1963; S. Wainwright, W. Newman; USNM 120279. 2♀, 23.3–45.5; lagoon, Canton Island, Phoenix Ids.; Sta. U-39-33; Apr. 25, 1939; L. P. Schultz; USNM 120278. 1♀, 29.5; Fakarava Id., Tuamotu Archipelago; shore in lagoon; *Albatross*; Oct. 11, 1899; USNM 120282. 2♀, 11.3–21.5; same; reef; *Albatross*; Oct. 13, 1899; USNM 120281. 1♂, 13.2; Bora Bora, Society Ids.; Smithsonian-Bredin Expedition, 1957; USNM 120280.

DESCRIPTION.—Basal portion of rostral plate broadly rounded anterolaterally.

Ocular scales small, rounded, separate.

Mandibular palp and 5 epipods present.

Lateral process of sixth thoracic somite truncate, broader than that of seventh somite.

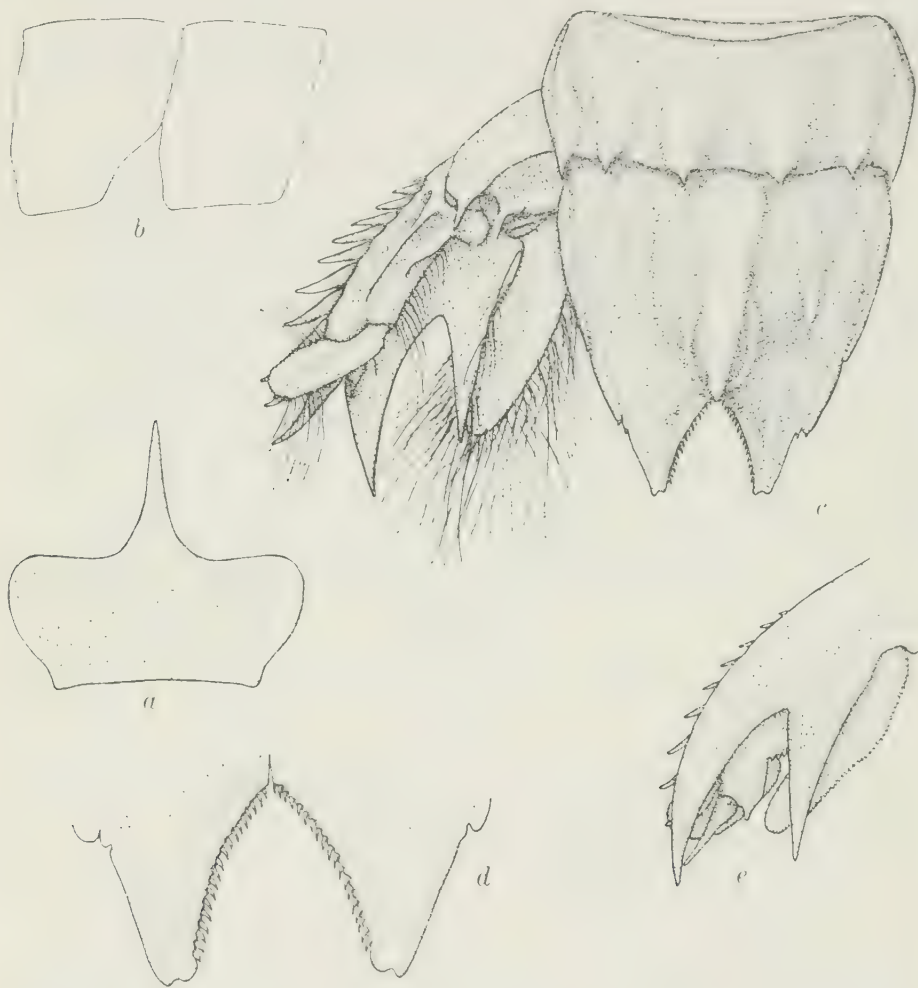


FIGURE 8.—*Gonodactylus espinosus* Borradaile, female, TL 45.5, Canton Island: *a*, rostral plate; *b*, lateral processes of sixth and seventh thoracic somites, lateral view (right side); *c*, last abdominal somite, telson, and uropod; *d*, submedian teeth of telson, ventral view; *e*, uropod, ventral view (setae omitted).

Sixth abdominal somite with 6 swollen carinae, each with small apical spine.

Telson length and width subequal, appearing elongate; 3 pairs of marginal teeth present, only submedians well developed, with movable apices; intermediate and lateral teeth poorly defined but present; dorsal surface of telson without spinules; median carina

elongate, tapering posteriorly, unarmed; accessory median carinae present on distal half or third of median, converging posteriorly with median to form an anchor; submedian carinae interrupted; carinae of intermediate and marginal teeth long, low; numerous small submedian denticles present; 1 small intermediate denticle present, situated at or posterior to apex of intermediate tooth; ventral surface of submedian teeth lacking longitudinal carina.

Basal segment of uropod lacking lobe or projection inside of dorsal carina; inner margin of proximal segment and all of distal segment of uropodal exopod with single row of setae; proximal segment of exopod with distal fixed spine under articulation of distal segment; endopod slender, tapered, margin with more than 1 row of slender setae, dorsal setae erect, especially on outer margin; basal prolongation of uropod produced into 2 spines, outer longer.

COLOR.—All specimens faded in preservative; Borradaile noted that his specimen was light green.

SIZE.—Only male examined, TL 13.2; females, TL 11.3–45.5. Borradaile's specimen, a male measured 18 mm. Other measurements of a female, TL 45.5: carapace length 9.7; fifth abdominal somite width 6.3; telson length 5.7, width 5.7.

DISCUSSION.—*G. espinosus* can be distinguished by the shape of its telson, with poorly defined intermediate and lateral marginal teeth, by the presence of several rows of setae on the outer margin of the uropodal endopod with some setae erect, and by the broad lateral process of the sixth thoracic somite. *Gonodactylus espinosus* shares this latter feature with *G. incipiens*.

The setation of the uropod may be reduced in small specimens, but the characteristic erect setae are always present.

It might be assumed from Borradaile's figure that the carinae of the telson in males are much more tumid than those of females; the telson of a female is figured here.

DISTRIBUTION.—Central Pacific Ocean, from Palmyra Id. (Edmondson, 1923) and Fanning Id., Line Ids.; Canton Island, Phoenix Ids.; Fakarava Id., Tuamotu Archipelago; Bora Bora, Society Ids.; and Rotuma, Fiji Ids. In shallow water, among reef corals in lagoons.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3619

Studies of Neotropical Caddis Flies, V

Types of the Species Described by Banks and Hagen

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Nathan Banks, who described his first Neotropical species in 1900 and his last in 1941, was one of the most prolific workers on Latin American Trichoptera. He described 94 species from South and Central America, Mexico, and the West Indies in 13 publications. Unfortunately, like many other workers of his time, he frequently did not figure the genitalia, and, when he did, he did not clear and relax this structure before preparing his figures. Thus, our attempts to recognize many of his species have been handicapped severely. Essentially the same situation exists with Hagen's six Neotropical species.

Very fortunately for North American workers, the types of all these species, save one, are located in the Museum of Comparative Zoology at Harvard University. I have been able to study all of this material and to make notes and sketches of the genitalia for most species. Although Banks very rarely possessed mixed type series, I am designating lectotypes in this paper for all species for which a syntypic series exists. Herein are given, with a few exceptions,

either figures of the genitalia of the types or specimens compared to the types, or a reference to published illustrations of the same, and photographs of the wings of certain species. The genera and species are listed in alphabetical order within the families, which are arranged in the order adopted by Ross (1944). The most detailed treatment is given under the combination, which in my estimation is correct. If the species was described originally in a different genus or is a synonym, it is listed in the original combination, together with the combination adopted in the present paper, directly under the generic heading.

I wish to express my sincere appreciation to Dr. P. J. Darlington and to Dr. H. E. Evans for their wholehearted cooperation during my visits to the Museum of Comparative Zoology.

RHYACOPHILIDAE

Genus *Atopsyche* Banks

Atopsyche batesi Banks

Atopsyche batesi Banks, 1938, p. 304.—Ross and King, 1952, p. 198.—Fischer, 1960, p. 161.

Lectotype, male: "Haiti 1934 M.Bates," "La Visite & vic. La Selle Range 5-7000 ft. Sept. 16-23," "M.C.Z.Type 22105," "A. batesi".

Ross and King (1952) have presented figures of the male genitalia of this species.

Atopsyche bolivari Banks

Atopsyche bolivari Banks, 1924, p. 443.—Ross and King, 1952, p. 195.—Fischer, 1960, p. 161.

Lectotype, male: "Monte Socorro Colombia, 3800m.," "Fassl Coll.," "N.Banks," "Type 14839," "Atopsyche bolivari Bks. Type."

Ross and King (1952) also have illustrated the genitalia of this specimen.

Atopsyche mexicana (Banks)

Philopotamus mexicanus Banks, 1901, p. 370.—Ulmer, 1905b, p. 68; 1907b, p. 197; 1913, p. 405.—Betten, 1934, p. 168.—Fischer, 1961, p. 15.
Atopsyche mexicana (Banks).—Ross, 1953, p. 293.

The holotype, from Mexico, is without abdomen and so can not now be identified specifically.

Genus *Dolochorema* Banks***Dolochorema irregularis* Banks**

Dolochorema irregularis Banks, 1913b, p. 240.—Ross, 1956a, p. 125.—Fischer, 1960, p. 160.

Ross (1956a) has given full figures of the genitalia and wings of the holotype male from Peru.

Genus *Rhyacophila* Pictet

Rhyacophila mexicana Banks: See *Chimarra mexicana* (Banks).

PHILOPOTAMIDAE**Genus *Chimarra* Stephens*****Chimarra (Curgia) banksi* (Ulmer), new combination****FIGURES 1-3**

Wormaldia mediana Banks, 1905, p. 18. [Preoccupied.]

Wormaldia banksi Ulmer, 1907b, p. 198; 1913, p. 405.—Navas, 1924, p. 75.—Betten, 1934, p. 170.—Fischer, 1961, p. 32.

The genitalia of the holotype male from Nicaragua are shown in figures 1-3.

Chimarra (Chimarra) bicolor* (Banks), new combination*FIGURES 13-15**

Philopotamus bicolor Banks, 1901, p. 370.—Ulmer, 1905b, p. 68; 1907b, p. 197; 1913, p. 405.—Betten, 1934, p. 168.—Fischer, 1961, p. 6.

Chimarra xesta Denning, 1952, p. 17. [New synonymy.]

Figures 13-15 were prepared from a topotype that is identical with the holotype, male. Denning's *xesta* is clearly a synonym and is also topotypic.

Chimarra (Curgia) mexicana* (Banks), new combination*FIGURES 4-7**

Rhyacophila mexicana Banks, 1900, p. 259.—Ulmer, 1907b, p. 210.—Betten, 1934, p. 135.—Fischer, 1960, p. 104.

Philopotamus barrettiae Banks, 1900, p. 259; 1901, p. 370.—Ulmer, 1905b, p. 68; 1907b, p. 197; 1913, p. 386, 405.—Betten, 1934, p. 168.—Fischer, 1961, p. 6. [New synonymy.]

Wormaldia mexicana Ulmer, 1905c, p. 89. [New synonymy.]

Chimarrha mexicana (Ulmer).—Ulmer, 1907b, p. 200; 1913, p. 405.—Betten, 1934, p. 176.

Chimarra mexicana (Ulmer).—Fischer, 1961, p. 66.—Flint, 1966, p. 3.

Figures 5-7 were prepared from the holotype male from Mexico. The holotype of *barrettiae* (fig. 4) is a female of this species. Although

barrettiae has line priority, I as first revisor, give *mexicana* precedence because its holotype is a male. Although the lectotype of *mexicana* (Ulmer) is without abdomen, the coloration and original figures of the male genitalia indicate that this too is a synonym.

***Chimarra (Chimarra) moesta* (Banks)**

FIGURE 16

Chimarrha (Curgia) moesta Banks, 1924, p. 449.—Betten, 1934, p. 176.

Chimarra moesta (Banks).—Fischer, 1961, p. 67.

The holotype, female, of this Cuban species is shown in figure 16.

***Chimarra (Curgia) persimilis* (Banks)**

FIGURES 11, 12

Chimarrha persimilis Banks, 1920, p. 360.—Lestage, 1925, p. 37.

Chimarra persimilis (Banks).—Fischer, 1961, p. 68.

Lectotype, male: "Quevedo W. Ecuador," "N. Banks," "Type 10907," "*Chimarrha persimilis* Bks. Type."

The lectotype is illustrated in figures 11 and 12.

***Chimarra (Curgia) pulchra* (Hagen)**

FIGURES 8-10

Chimarrha pulchra Hagen, 1861, p. 298; 1864, p. 809.—Kolbe, 1888, pp. 167, 175.—Ulmer, 1905b, p. 69; 1907b, p. 200; 1909, p. 127; 1913, p. 405.—Betten, 1934, p. 176.—Ross 1952, p. 32.

Chimarrha (Curgia) fraterna Banks, 1924, p. 449.—Betten, 1934, p. 176. [New synonymy.]

Chimarra pulchra (Hagen).—Fischer, 1961, p. 69.

Chimarra fraterna (Banks).—Fischer, 1961, p. 60.

Ross designated the lectotype of *pulchra*; I designate here the lectotype, male, of *fraterna*: "Cuba Ch. Wright," "Type 14876."

The extent of golden hairs on the forewings is somewhat variable. The lectotype of *fraterna* has the patch somewhat divided; otherwise, it is identical to *pulchra*.

A male of this common Cuban species is illustrated in figures 8-10.

***Chimarra (Curgia?) pumila* (Banks)**

FIGURE 17

Chimarrha pumila Banks, 1920, p. 359.—Lestage, 1925a, p. 37.

Chimarra pumila (Banks).—Fischer, 1961, p. 69.

Lectotype, female: "Quevedo W. Ecuador," "N. Banks," "Type 10908," "*Chimarrha pumila* Bks. Type."

The female lectotype is illustrated (fig. 17) herein. It is probably the female of *C. persimilis* Banks.

Genus *Chimarrha* Burmeister

- Chimarrha fraterna* Banks: See *Chimarra pulchra* (Hagen).
Chimarrha moesta Banks: See *Chimarra moesta* (Banks).
Chimarrha persimilis Banks: See *Chimarra persimilis* (Banks).
Chimarrha pulchra Hagen: See *Chimarra pulchra* (Hagen).
Chimarrha pumila Banks: See *Chimarra pumila* (Banks).

Genus *Philopotamus* Stephens

- Philopotamus barrettiae* Banks: See *Chimarra mexicana* (Banks).
Philopotamus bicolor Banks: See *Chimarra bicolor* (Banks).
Philopotamus mexicanus Banks: See *Atopsyche mexicana* (Banks).

Genus *Wormaldia* McLachlan

- Wormaldia mediana* Banks: See *Chimarra banksi* (Ulmer).

PSYCHOMYIIDAE**Genus *Antillopsyche* Banks*****Antillopsyche wrighti* Banks****FIGURE 18**

Antillopsyche wrighti Banks, 1941, p. 400.

Lectotype, male: "Soledad Santa Clara Prov. 1-8-VI," "Cuba 1939 C. T. Parsons," "M.C.Z. Type 25294," "Antillopsyche wrighti Bks. Type."

The male lectotype is illustrated in figure 18. The genus is distinct and close to *Pseudoneureclipsis* Ulmer (see Flint, 1964, p. 29).

Genus *Cordillopsyche* Banks

- Cordillopsyche costalis* Banks: See *Polyplectropus costalis* (Banks).

Genus *Cyrnellus* Banks***Cyrnellus minimus* Banks****FIGURES 19, 20**

Cyrnellus minimus Banks, 1913a, p. 88.—Lestage, 1925b, p. 105.—Fischer, 1962, p. 143.

Lectotype, male: "type," "Camp 41; 360 Km from Porto Velho Brazil, Mann," "Type 11806," "Cyrnellus minimus Bks. Type."

The male lectotype is shown in figures 19 and 20.

Genus *Polycentropus* Curtis***Polycentropus colombiensis* Banks**

FIGURE 25

Polycentropus colombiensis Banks, 1910, p. 160.—Ulmer, 1913, p. 406.—Lestage, 1925b, p. 109.—Fischer, 1962, p. 67.

The female holotype of this species, from Colombia, is illustrated in figure 25.

***Polycentropus domingensis* Banks**

FIGURE 21

Polycentropus domingensis Banks, 1941, p. 399.

Lectotype, male: "Loma Rucilla June '38 Dom. Rep. 5-10,000 ft. Darlington," "M.C.Z. Type 25,293," "Polycentropus domingensis Bks. Type."

The lectotype male is illustrated in figure 21.

***Polycentropus insularis* Banks**

FIGURE 24

Polycentropus insularis Banks, 1938, p. 302.—Fischer, 1962, p. 83.

Lectotype, male: "Grenada: Grand Etang Sept. 1910 Allen & Brues," "M.C.Z. Type 22111," "Polycentropus insularis Bks. Type."

The genitalia of the lectotype are illustrated in figure 24.

***Polycentropus mexicanus* (Banks), new combination**

FIGURE 23

Hydropsyche mexicana Banks, 1901, p. 369.—Ulmer, 1905b, p. 68; 1907b, p. 171; 1913, p. 406.—Betten, 1934, p. 193.—Fischer, 1963, p. 55.

The male holotype from Mexico is shown in figure 23.

***Polycentropus nigriceps* Banks**

FIGURE 22

Polycentropus nigriceps Banks, 1938, p. 301.—Fischer, 1962, p. 90.

Lectotype, male: "Soledad, Cuba (Cienfuegos) Apr. 1936 Darlington," "Cuba 1936 Darlington Collector," "M.C.Z. Type 22674," "Polycentropus nigriceps Bks. Type".

The male lectotype is shown in figure 22.

Genus *Polyplectropus* Ulmer

(Genus *Cordillopsyche* Banks, new synonymy)

The genus *Cordillopsyche* Banks (type-species *C. costalis* Banks) is clearly synonymous with *Polyplectropus* Ulmer (type-species *P.*

flavicornis Ulmer) on the basis of venation and general structure of the female genitalia.

***Polyplectropus costalis* (Banks), new combination**

FIGURES 26, 27

Cordillopsyche costalis Banks, 1913b, p. 238.—Lestage, 1925b, p. 105.—Fischer, 1962, p. 95.

The genitalia of the female holotype of this Colombian species are shown in figures 26 and 27.

Genus *Xiphocentron* Brauer

***Xiphocentron cubana* (Banks)**

Antillotrichia cubana Banks, 1941, p. 401.

Xiphocentron cubana (Banks).—Flint, 1964, p. 26.

The holotypic male has lost all parts of the genital capsule beyond the ninth segment. The parts remaining and the original drawing indicate that this is a typical species of *Xiphocentron*.

***Xiphocentron haitiensis* (Banks)**

Antillotrichia haitiensis Banks, 1941, p. 402.

Xiphocentron haitiensis (Banks).—Flint, 1964, p. 26.

This species was described from a male holotype from Haiti. The genitalia were illustrated by Flint (1964).

HYDROPSYCHIDAE

Subfamily Macronematinae

Genus *Centromacronema* Ulmer

Centromacronema extensum Banks: See *Centromacronema auripenne* (Rambur).

***Centromacronema auripenne* (Rambur)**

Macronema auripenne Rambur, 1842, p. 507.

Centromacronema auripenne (Rambur).—Ulmer, 1905b, p. 87.—Fischer, 1963, p. 202.

Centromacronema extensum Banks, 1913b, p. 238.—Betten, 1934, p. 203.—Fischer, 1963, p. 204. [New synonymy.]

I am not presenting a complete synonymy of *auripenne*; rather, one may consult the extensive bibliography in Fischer (1963).

The holotype of *extensum* seems to fall well within the extremes of the very variable *auripenne*.

***Centromacronema nigrifrons* Banks**

Centromacronema nigrifrons Banks, 1913b, p. 238.—Fischer, 1963, p. 204.

Although the holotype, male, from Colombia, shows no genitalic differences from *C. apicale* (Walker), I am not synonymizing it here because of the color differences pointed out in the original description.

Genus *Leptonema* Guerin

Leptonema externum Banks: See *Leptonema columbianum* Ulmer.

Leptonema guatemalum Banks: See *Leptonema albovirens* (Walker).

***Leptonema albovirens* (Walker)**

Macronema albovirens Walker, 1852, p. 76.

Leptonema albovirens (Walker).—Ulmer, 1905a, p. 31.—Fischer, 1963, p. 166.

Leptonema guatemalum Banks, 1913a, p. 89.—Mosely, 1933a, p. 65.—Betten, 1934, p. 202.—Fischer, 1963, p. 169. [New synonymy.]

A more extensive bibliography of *albovirens* and *columbianum* are given by Fischer (1963).

The holotype male of *guatemalum* is identical to the type of *albovirens*, as figured by Mosely.

***Leptonema columbianum* Ulmer**

Leptonema columbianum Ulmer, 1905a, p. 61.—Fischer, 1963, p. 168.

Leptonema externum Banks, 1913a, p. 87.—Mosely, 1933a, p. 13.—Fischer, 1963, p. 168.

The holotype, female, of *externum* agrees with *columbianum* in having 2 dark spots basally on the forewing, and expanded tibiae and tarsi of the midlegs.

***Leptonema insulanum* Banks**

Leptonema insulanum Banks, 1924, p. 455.—Mosely, 1933a, p. 66.—Betten, 1934, p. 202.—Fischer, 1963, p. 169.—Flint, 1964, p. 36.

This species, known from Puerto Rico only by the male holotype, is the senior synonym of *L. ulmeri* Mosely. I have a long series from Venezuela, which makes me suspect that the Puerto Rican specimen may be mislabelled.

***Leptonema poeyi* (Banks), new combination**

FIGURES 28-31

Macronema poeyi Banks, 1938, p. 299.—Fischer, 1963, p. 194.

Lectotype, male: "Coast below Pico Turquino June 26-30, '36," "Cuba 1936 Darlington Collector," "M.C.Z. Type 22675," "*Macronema poeyi* Bks. Type."

This species, the lectotype of which is shown here (figs. 28-31), clearly belongs in *Leptonema*.

Genus *Macronema* Pictet

The taxonomic situation in this genus in the American tropics is, at best, extremely confusing. To add to the difficulty, many of the species are known only from a single specimen, often a female. The group of species near *hyalinum* Pictet (including *ulmeri* Banks and *erichsoni* Banks) seem to have distinctive color patterns but no obvious differences in the male genitalia. On the basis of color alone specimens of *ulmeri* can be recognized from Peru to Panama and Surinam. Another group is centered on *digramma* McLachlan (including *subaequalis* Banks). In this group, every specimen looks different from the next, but all could be the result of different degrees of development of the same basic pattern. The genitalia of the few males seen look identical and, in fact, are not clearly different from those of the *hyalinum* group. The *percitans* group (including the remainder of the Banks species) offer differences in the genitalia, especially the tenth tergum and aedeagus, often coupled with recognizable color differences. Yet the genitalia of *percitans* and *picteti* seem identical, although the coloration is quite different.

Banks has sketched (1924) the tips of the forewings showing the color pattern of *lachlani*, *burmeisteri*, *muelleri*, *pertyi*, *fraternum*, *hageni*, and *braueri*.

Macronema aeneum Hagen: See *Phylloicus aeneus* (Hagen).

Macronema chalybeum Hagen: See *Phylloicus chalybeus* (Hagen).

Macronema poeyi Banks: See *Leptonema poeyi* (Banks).

Macronema braueri Banks

Macronema braueri Banks, 1924, p. 454.—Fischer, 1963, p. 178.

This Brazilian species is known only from the female holotype.

Macronema burmeisteri Banks

Macronema burmeisteri Banks, 1924, p. 452.—Fischer, 1963, p. 178.

Lectotype, female: "Yurimaguas Peru 10 April Parish Coll," "Type 14836," "*Macronema burmeisteri* Bks. Type."

This species is known from the female sex.

Macronema erichsoni Banks

PLATE 1F

Macronema hyalinum Pictet, var.—Ulmer, 1913, p. 395.

Macronema erichsoni Banks, 1920, p. 356.—Mosely, 1931, p. 170.—Fischer, 1963, p. 184.

The photograph (pl. 1F) of the wings was made from a specimen identical to the female holotype in coloration. The species was

described from French Guiana and is also known from Brazil and Dutch Guiana.

***Macronema fragilis* Banks**

FIGURES 41-43

Macronema fragilis Banks, 1915, p. 631.—Mosely, 1931, p. 170.—Fischer, 1963, p. 187.

The illustrations (figs. 41-43) of the genitalia were made from the male holotype. The species is known from British Guiana.

***Macronema fraternum* Banks**

FIGURES 32-34; PLATE 1C

Macronema fraterna Banks, 1910, p. 159.—Ulmer, 1913, p. 408.—Banks, 1924, p. 453.—Mosely, 1931, p. 170.—Fischer, 1963, p. 187.

The holotype is a female from British Guiana. The photograph of the wings (pl. 1c) and figures 32-34 of the male genitalia are from a specimen carefully compared with the type. I have seen specimens from the Guianas and Ecuador.

***Macronema gundlachi* Banks**

FIGURES 35-37

Macronema gundlachi Banks, 1924, p. 454.—Betten, 1934, p. 207.—Fischer, 1963, p. 187.

Lectotype, male: $\frac{89}{9}$, "Cuba Gundlach 1864," "Hagen," "Type 14875," "Macronema gundlachi Bks. Type."

The genitalia of the male lectotype are shown in figures 35-37.

***Macronema hageni* Banks**

FIGURES 47-49; PLATE 1B

Macronema hageni Banks, 1924, p. 452.—Mosely, 1931, p. 170.—Fischer, 1963, p. 187.

Lectotype, male: "Tapajos Brazil 30 June Parish," "Type 14834," "Macronema hageni Bks. Type."

Figures 47-49 of the genitalia were made from the lectotype. The wing photograph (pl. 1B) is from a specimen carefully compared with the type.

***Macronema lachlani* Banks**

FIGURES 44-46

Macronema lachlani Banks, 1924, p. 452.—Fischer, 1963, p. 189.

Figures 44-46 of the male genitalia were made from the male holotype. The species was described from Brazil.

***Macronema muelleri* Banks**

FIGURES 38-40

Macronema mülleri Banks, 1924, p. 453.—Fischer, 1963, p. 191.

Lectotype, male: "Flores Brazil 6-XI Parish," "Type 14837."

The genitalia of the lectotype male are shown in figures 38-40.

Macronema pertyi* BanksMacronema pertyi* Banks, 1924, p. 451.—Fischer, 1963, p. 193.

The holotype is a female from Brazil.

***Macronema picteti* Banks**

PLATE 1A

Macronema percitans Walker, var.—Ulmer, 1913, p. 395.*Macronema picteti* [sic] Banks, 1915, p. 631.—Mosely, 1931, p. 170.—Fischer, 1963, p. 194.

The photograph (pl. 1A), which, unfortunately, does not show clearly the golden patch beyond the transverse white line, was made from a specimen carefully compared with the type. The male genitalia are identical to those shown by Betten and Mosely (1940, fig. 102) for *percitans* Walker. Yet, because the coloration seems quite different, I am not synonymizing the two here.

***Macronema subaequalis* Banks**

FIGURES 50-52

Macronema subaequalis Banks, 1920, p. 355.*Pseudomacronema subaequalis* (Banks).—Fischer, 1963, p. 163.

The genitalia of the male holotype of this Argentinian species are shown in figures 50-52.

***Macronema ulmeri* Banks**

FIGURE 53; PLATE 1D

Macronema hyalinum Pictet, var.—Ulmer, 1907c, p. 76; 1913, p. 395.*Macronema ulmeri* Banks, 1913b, p. 237.—Fischer, 1963, p. 199.

The holotype is a male from Colombia. The photograph of the wings (pl. 1D) and drawing of the male genitalia (fig. 53) were made from a specimen identical with the type.

Genus *Plectromacronema* Ulmer(Genus *Podomacronema* Banks, new synonymy)

A study of the genitalia, wings and coloration of *subfuscum* Banks and *comptum* Ulmer, the type-species of *Plectromacronema*, convinces

me that the two are congeneric. I, therefore, synonymize *Podomacronema* Banks with *Plectromacronema* Ulmer (new synonymy).

***Plectromacronema subfuscum* (Banks), new combination**

FIGURES 54-56; PLATE 1E

Podomacronema subfuscum Banks, 1920, p. 356.—Fischer, 1963, p. 164.

Figures 54-56 of the genitalia were made from the male holotype from Argentina. The wing photograph (pl. 1E) was made from a specimen identical with the holotype.

Genus *Podomacronema* Banks

Podomacronema subfuscum Banks: See *Plectromacronema subfuscum* (Banks).

Subfamily Hydropsychinae

Genus *Diplectrona* Westwood

Diplectrona unicolor Banks: See *Smicridea unicolor* (Banks).

Genus *Hydropsyche* Pictet

Hydropsyche ? *bivittata* Hagen: See *Smicridea bivittata* (Hagen).

Hydropsyche mexicana Banks: See *Polycentropus mexicanus* (Banks).

***Hydropsyche calosa* Banks**

Hydropsyche calosa Banks, 1938, p. 300.—Flint, 1962, p. 23.—Fischer, 1963, p. 24.

Lectotype, male: "Cuba Ch. Wright," "M.C.Z. Type 22673," "Hydropsyche calosa Bks. Type."

The lectotype, male, was figured by Flint (1962).

***Hydropsyche domingensis* Banks**

Hydropsyche domingensis Banks, 1941, p. 398.—Flint, 1962, p. 24.—Fischer, 1963, p. 28.

Lectotype, female: "Constanza to Jarabacoa Aug '38, Dom. Rep. 2-4,000 ft., Darl.," "M.C.Z. Type 25291."

The lectotype female was figured by Flint (1962).

Genus *Rhyacophylax* Muller

Rhyacophylax varius Banks: See *Smicridea varius* (Banks).

Genus *Smicridea* McLachlan

Smicridea maculata Banks: See *Smicridea albosignata* Ulmer.

Smicridea unicolor Banks: See *Smicridea banksi* Flint.

Smicridea aequalis Banks

FIGURES 74, 75

Smicridea aequalis Banks, 1920, p. 358.—Mosely, 1931, p. 170; 1933b, p. 220.—Fischer, 1963, p. 130.

Figures 74 and 75 of the male genitalia were made from the holotype. Although considerably rubbed, the type appears to have had a transverse white band from the stigma and another pale patch nearer the wing base.

Smicridea albosignata Ulmer

FIGURES 76, 77

Chimarrha ? maculata Hagen, 1861, p. 329. [Nomen nudum.]

Smicridea albosignata Ulmer, 1907a, p. 34; 1907b, p. 175; 1913, p. 390.—Mosely, 1933b, p. 216, 220.—Betten, 1934, p. 199.—Fischer, 1963, p. 131.

Smicridea maculata Banks, 1920, p. 359.—Mosely, 1933b, p. 220.—Fischer, 1963, p. 133. [New synonymy.]

The holotype of *maculata* was compared to a syntype of *albosignata* at the MCZ and found to be essentially identical. Figures 76 and 77 were prepared from a specimen carefully compared with the syntype. All examples are from Brazil.

Smicridea banksi Flint, new name

FIGURES 61–63

Smicridea unicolor Banks, 1938, p. 303.—Fischer, 1963, p. 135. [Preoccupied by *Smicridea unicolor* (Banks), 1901.]

Lectotype, male: "La Visite & vic. La Selle Range 5–7000 ft. Sept. 16–23," "Haiti 1934 M. Bates," "M.C.Z. Paratype 22110," "S. unicolor."

The male labelled "paratype" is selected as lectotype because its genitalia are undamaged. Figures 61–63 were prepared from this specimen. This species has a very faint transverse pale band from the stigma.

Smicridea bivittata (Hagen)

FIGURES 71–73

Hydropsyche bivittata Hagen, 1861, p. 291; 1864, p. 821.—Ulmer, 1905b, p. 68; 1907b, p. 171.—Ross, 1952, p. 33.

Smicridea bivittata (Hagen).—Ulmer, 1913, p. 390.—Betten, 1934, p. 199.—Fischer, 1963, p. 131.

The female lectotype, selected by Ross, was compared carefully with a female from a series containing males. This species is one of several with two narrow, white, transverse bands on the forewing. The species was described from Panama.

Smicridea comma Banks

FIGURES 59, 60

Smicridea comma Banks, 1924, p. 451.—Mosely, 1933b, p. 220.—Betten, 1934, p. 199.—Banks, 1941, p. 399.—Fischer, 1963, p. 132.

Lectotype, female: "1," "Cuba Poey 1864," "Hagen," "Type 14874," "*Smicridea comma* Bks. Type."

The type series contains only females. Figures 59 and 60 were prepared from a male identical with the type in maculation. The wings are brown with a white comma-shaped mark at the stigma and another transverse white band basad.

Smicridea completa Banks

FIGURES 64, 65

Smicridea completa Banks, 1941, p. 398.—Fischer, 1963, p. 132.

Lectotype, male: "Villa Altagracia July '38, Dom. Rep. Darlington," "M.C.Z. Type 25292," "*Smicridea completa* Bks. Type."

Figures 64 and 65 were prepared from the lectotype. This species bears on the forewing a transverse white band from the stigma and a diffuse band basad.

Smicridea nigripennis Banks

FIGURES 78-80

Smicridea nigripennis Banks, 1920, p. 359.—Mosely, 1933b, pp. 216, 220.—Fischer, 1963, p. 134.

Lectotype, male: "Caldras Columbia 4400 ft.," "N. Banks," "Type 10912," "*Smicridea nigripennis* Bks. Type."

The lectotype is a perfect match in color and male genitalia with the topotypic male shown here in figures 78-80.

Smicridea obesa Banks

FIGURES 57, 58

Smicridea obesa Banks, 1938, p. 303.—Fischer, 1963, p. 134.

Lectotype, male: "Pico Turquino June 16-21, 1936 6000 ft. (summit)," "Cuba 1936 Darlington Collector," "M.C.Z. Type 22672," "*Smicridea obesa* Bks. Type."

Figures 57 and 58 were prepared from the lectotype. The specimen has immaculate wings, but an associated female bears an incomplete white transverse line from the stigma.

***Smicridea unicolor* (Banks)**

FIGURES 66, 67

Diplectrona unicolor Banks, 1901, p. 370.—Ulmer, 1905b, p. 68; 1907b, p. 177; 1913, p. 407.—Betten, 1934, p. 183.—Fischer, 1963, p. 150.

Smicridea unicolor (Banks).—Ross, 1947, p. 144.

Lectotype, male: "type," "Cuernavaca June," "Collection N. Banks," "Type 11815," "Diplectrona unicolor Bks. type."

The lectotype is shown in figures 66 and 67; its wings are uniformly reddish brown.

***Smicridea varius* (Banks), new combination**

FIGURES 68-70

Rhyacophylax varius Banks, 1913b, p. 239.—Lestage, 1925a, p. 41.—Betten, 1934, p. 199.—Fischer, 1963, p. 137.

The holotypic male agrees in maculation and genitalia with the male in figures 68-70. The species was described from Costa Rica.

HYDROPTILIDAE**Genus *Antillotrichia* Banks**

Antillotrichia cubana Banks: See *Xiphocentron cubana* (Banks).

Antillotrichia haitiensis Banks: See *Xiphocentron haitiensis* (Banks).

LIMNEPHILIDAE**Genus *Algonquina* Banks**

Algonquina chilensis Banks: See *Magellomyia appendiculata* (Ulmer).

Genus *Hallesus* Stephens

Hallesus [sic] *solidus* Hagen: See *Limnephilus solidus* (Hagen).

Genus *Ironoquia* Banks

Ironoquia australis Banks: See *Magellomyia capillata* (Ulmer).

Genus *Limnephilus* Leach***Limnephilus discolor* (Banks)**

Platyphylax discolor Banks, 1901, p. 367.—Ulmer, 1905b, p. 21, 120; 1907b, p. 54; 1913, p. 410.—Betten, 1934, p. 352.

Limnephilus discolor (Banks).—Flint, 1963, p. 211.—Denning and Sykora, 1966, p. 1222.

The male holotype of this Mexican species was recently figured by Flint (1963) and the female by Denning and Sykora (1966).

***Limnephilus solidus* (Hagen)**

Hallesus [sic] *solidus* Hagen, 1861, p. 267; 1864, p. 818.—Ulmer, 1905b, p. 21; 1907b, p. 56; 1913, p. 411.—Betten, 1934, p. 350.

Limnephilus solidus (Hagen).—Flint, 1963, p. 213.

The type of this species is not found in the Hagen material at the MCZ. It may well be found in the Zoologische Museum, Humboldt Universität, Berlin, where other types with the data "Mexico, Deppe" were found by Byers (1962).

***Limnephilus toussainti* Banks**

Limnephilus toussianti [sic] Banks, 1924, p. 439.—Betten, 1934, p. 337.—Flint, 1963, p. 211.

The male holotype, figured by Flint (1963), is labelled as being from "Haiti." This is apparently in error as I now have seen examples collected in northwestern Mexico.

Genus *Magellomyia* Banks

Magellomyia moesta Banks: See *Magellomyia appendiculata* (Ulmer).

***Magellomyia appendiculata* (Ulmer)**

Stenophylax appendiculatus Ulmer, 1904, p. 19; 1905b, p. 21; 1907b, p. 50.

Limnophilus appendiculatus (Ulmer).—Ulmer, 1913, p. 403.—Jorgensen, 1919, p. 398.

Magellomyia moesta Banks, 1920, p. 348.—Schmid, 1955, p. 54.

Algonquina chilensis Banks, 1920, p. 347. [New synonymy.]

Magellomyia appendiculata (Ulmer).—Schmid, 1955, p. 54; 1957, p. 389; 1958, p. 205; 1964, p. 323.—Flint, 1967, p. 58.

Magellomyia chilensis (Banks).—Schmid, 1955, p. 54.

The male holotype of *moesta* was studied by Schmid, who synonymized the name with *appendiculata*. I also am synonymizing here *A. chilensis* Banks, whose holotype is an absolutely typical female of *appendiculata*. The male genitalia were illustrated by Flint (1967).

***Magellomyia capillata* (Ulmer)**

Limnophilus capillatus Ulmer, 1906, p. 11; 1907b, p. 45; 1913, p. 410.—Jorgensen, 1919, p. 398.

Ironoquia australis Banks, 1920, p. 347.—Schmid, 1955, p. 53.

Magellomyia capillata (Ulmer).—Schmid, 1955, p. 53; 1957, p. 388; 1964, p. 324.

Lectotype, male: "Chile Fairm.," "Hagen," "Type 10868," "L. capillatus Ulm. ♂ F. Schmid 1951."

The lectotypic male was studied by Schmid, who recognized the above synonymy and figured the species (1955).

Genus *Platyphylax* McLachlan

Platyphylax discolor Banks: See *Limnephilus discolor* (Banks).

CALAMOCERATIDAE

Genus *Heteroplectron* McLachlan

Heteroplectron maculatum Banks: See *Phylloicus maculatus* (Banks).

Heteroplectron nigripennis Banks: See *Phylloicus aeneus* (Hagen).

Heteroplectron mexicanum Banks: See *Phylloicus aeneus* (Hagen).

Genus *Phylloicus* Müller

(Genus *Notiomyia* Banks, new synonymy)

I am synonymizing here the genus *Notiomyia* with *Phylloicus*. The type-species of *Notiomyia*, *mexicana* (Banks), is clearly congeneric with *P. major* Müller, the type-species of *Phylloicus*. The species presently placed in *Notiomyia*—*mexicana* (Banks), *ornata* Banks, and *sagittosa* Ross—are all transferred to *Phylloicus* (all new combinations).

Phylloicus aeneus (Hagen)

FIGURES 90-92

Macronema aeneum Hagen, 1861, p. 285.—Ross, 1952, p. 34.

Anisocentropus aeneus (Hagen).—Hagen, 1864, p. 804.—Kolbe, 1888, p. 167.—Ulmer, 1905b, p. 30.

Heteroplectron nigripennis Banks, 1900, p. 256; 1901, p. 369.—Ulmer, 1905b, p. 30. [New synonymy.]

Heteroplectron mexicanum Banks, 1900, p. 257; 1901, p. 369.—Ulmer, 1905b, p. 30. [New synonymy.]

Phylloicus aeneus (Hagen).—Ulmer, 1905c, p. 79; 1906, p. 58; 1907b, p. 120; 1913, p. 409.—Betten, 1934, p. 237.—Fischer, 1965, p. 20.

Notiomyia mexicana (Banks).—Banks, 1905, p. 18; 1907, p. 43.—Ulmer, 1907b, p. 121; 1913, p. 409.—Essig, 1926, p. 177.—Betten, 1934, p. 236.—Milne, 1936, p. 78.—Ross, 1944, p. 301.—Fischer, 1965, p. 19.

Phylloicus nigripennis (Banks).—Ulmer, 1907b, p. 210; 1913, pp. 398, 409.—Betten, 1934, p. 237.—Fischer, 1965, p. 23.

Notiomyia sagittosa Ross, 1951, p. 72.—Denning, 1964, p. 134. [New synonymy.]

This species is, as I am considering it here, quite variable in coloration, size, and details of structure of the genitalia. The types of *aeneus* and *nigripennis* are females whose abdomens I have cleared and compared side-by-side and found to be the same. In coloration, there is a form with the wing veins marked with golden hairs (*aeneus* and *sagittosa* types) and another with totally black hairs (*nigripennis*

and *mexicanus* types). I have taken several pairs in copula in which one sex is one form, the other the other form. The examples from the southern part of the range seem smaller and with more orange on the body (*aeneus*, *nigripennis*, and *sagittosa* types), while the more northern populations seem larger with only the pronotum and a mesal spot on the head orange (*mexicanus* type). The exact shape of the tenth tergum varies in every population I have studied.

Figures 90–92 of the male were prepared from an example with the data “Mexico, Sallé,” which was probably part of the original series.

***Phylloicus brevior* Banks**

FIGURES 97, 98

Phylloicus brevior Banks, 1915, p. 632.—Lestage, 1925a, p. 44.—Mosely, 1931, p. 170.—Fischer, 1965, p. 21.

Figures 97, 98 were prepared from the male holotype from British Guiana.

***Phylloicus cubanus* Banks**

FIGURES 81, 82

Phylloicus cubanus Banks, 1924, p. 445.—Betten, 1934, p. 237.—Banks, 1938, p. 298; 1941, p. 397.—Fischer, 1965, p. 22.

Because the male holotype is lacking the cerci, figures 81 and 82 were prepared from another specimen identical with the type.

***Phylloicus chalybeus* (Hagen)**

FIGURES 83, 84

Macronema chalybeum Hagen, 1861, p. 285; 1864, p. 845.—Kolbe, 1888, p. 167.—Ulmer, 1905b, p. 32; 1905c, p. 83; 1907b, p. 164; 1907c, p. 64, 81; 1913, p. 408.—Ross, 1952, p. 34.

Anisocentropus chalybeus (Hagen).—Betten, 1934, p. 232.—Fischer, 1965, p. 3.

Phylloicus chalybeus (Hagen).—Banks, 1941, p. 397.

Ross designated the lectotype, which is shown in figures 83 and 84. The species is known from Cuba.

***Phylloicus iridescens* Banks**

FIGURES 85, 86

Phylloicus iridescens Banks, 1941, p. 397.—Fischer, 1965, p. 22.

Lectotype, male: “Constanza to V. Nuevo, Dom. Rep. Aug. '38, 3–7,000 ft. Darlington,” “M.C.Z. Type 25297,” “*Phylloicus iridescens* Bks. type.”

Figures 85 and 86 were prepared from the lectotype.

***Phylloicus lituratus* Banks**

FIGURES 93, 94

Phylloicus lituratus Banks, 1920, p. 350.—Lestage, 1925a, p. 42.—Fischer, 1965, p. 22.

The genitalia of the male holotype from Colombia are illustrated in figures 93 and 94.

***Phylloicus maculatus* (Banks), new combination**

FIGURE 89

Heteroplectron maculatum Banks, 1901, p. 369.—Ulmer, 1905b, p. 30; 1907b, p. 119; 1913, p. 409.—Banks, 1914, p. 150.—Betten, 1934, p. 233.—Fischer, 1965, p. 19.

The genitalia of the female holotype are shown in figure 89. The type is from Mexico.

***Phylloicus magnus* Banks**

FIGURES 95, 96

Phylloicus magnus Banks, 1913b, p. 236.—Lestage, 1925a, p. 42.—Fischer, 1965, p. 22.

Figures 95 and 96 were prepared from the male holotype, which is from Colombia.

***Phylloicus superbus* Banks**

FIGURES 87, 88

Phylloicus superbus Banks, 1938, p. 298; 1941, p. 397.—Fischer, 1965, p. 23.

Lectotype, male: "Pico Turquino N. side June 18–20, 1935 4500–6000 ft.," "Cuba 1936 Darlington Collector," "M.C.Z. Type 22669," "*Phylloicus superbus* Bks. type."

Figures 87 and 88 were prepared from the lectotype.

ODONTOCERIDAE**Genus *Marilia* Müller*****Marilia fasciculata* Banks**

FIGURE 119

Marilia fasciculata Banks, 1913a, p. 86.—Fischer, 1965, p. 32.

Figure 119 was prepared from the male holotype from Brazil.

***Marilia gracilis* Banks**

FIGURES 110, 111

Marilia gracilis Banks, 1938, p. 297.—Fischer, 1965, p. 33.

Lectotype, male: "La Visite & Vic La Selle Range 5–7000 ft. Sept.

16-23," "Haiti 1934 M. Bates," "M.C.Z. Type 22107," "*Marilia gracilis* Bks. type."

Figures 110 and 111 were prepared from the lectotype.

***Marilia gracilis nigrescens* Banks**

FIGURE 112

Marilia gracilis var. *nigrescens* Banks, 1941, p. 397.—Fischer, 1965, p. 33.

Lectotype, male: "Valle Nuevo S E Constanza Aug. '38, Dom. Rep. c. 7,000 ft., Darl.," "M.C.Z. Type 25298," "*Marilia gracilis nigrescens* Bks. type."

The clasper of the lectotype male is shown in figure 112.

***Marilia mexicana* (Banks), new combination**

FIGURES 120, 121

Leptocerus mexicanus Banks, 1901, p. 368.—Ulmer, 1905b, p. 28; 1907b, p. 136; 1913, p. 410.—Betten, 1934, p. 263.

Athripsodes mexicanus (Banks).—Fischer, 1965, p. 211.

The genitalia of the female holotype from Mexico are illustrated in figures 120 and 121.

***Marilia modesta* Banks**

FIGURES 117, 118

Marilia modesta Banks, 1913b, p. 235.—Fischer, 1965, p. 34.

The genitalia of the male holotype from Colombia are shown in figures 117 and 118.

***Marilia scudderi* Banks**

FIGURES 113, 114

Marilia scudderi Banks, 1924, p. 446.—Betten, 1934, p. 242.—Fischer, 1965, p. 34.

Figures 113 and 114 were prepared from the male holotype. The species is known from the Isle of Pines near Cuba.

***Marilia wrighti* Banks**

FIGURES 115, 116

Marilia wrighti Banks, 1924, p. 446.—Betten, 1934, p. 242.—Fischer, 1965, p. 35.

Lectotype, male: "Cuba. Ch. Wright," "Type 14873," "*Marilia wrighti* Bks. type."

Figures 115 and 116 were prepared from the lectotype.

LEPTOCERIDAE

Genus *Leptocella* Banks

Leptocella fenestrata Banks: See *Leptocella punctata* Ulmer.

Leptocella pulchella Banks: See *Leptocellodes pulchellus* (Banks).

Leptocella sparsa Banks: See *Leptocella flavofasciata* Ulmer.

***Leptocella cubana* Banks**

FIGURE 99

Leptocella cubana Banks, 1938, p. 299.—Fischer, 1966, p. 53.

Lectotype, male: "Guineo(s) Cuba April," "M.C.Z. Type 22671," "*Leptocella cubana* Bks. type."

Figure 99 was made from the lectotype.

***Leptocella diminuta* Banks**

FIGURE 102

Leptocella diminuta Banks, 1920, p. 353.—Mosely, 1931, p. 170.—Fischer, 1966, p. 54.

Lectotype, male: "Bartica Br. Guiana Dec.," "N. Banks," "Type 10900," "*Leptocella diminuta* Bks. type."

Figure 102 was prepared from the lectotype. The other specimens in the type series are another species of the genus. The eyes of the lectotype are extremely large.

***Leptocella dorsalis* Banks**

FIGURE 100

Leptocella dorsalis Banks, 1901, p. 368.—Ulmer, 1905b, p. 28; 1907b, p. 138; 1913, p. 402, 410.—Betten, 1934, p. 267.—Fischer, 1966, p. 54.

The species was described from Mexico from a female holotype. Figure 100 of the male genitalia was prepared from a topotypic male. The eyes of the male of this species are very large, being separated by less than half their width ventrally.

***Leptocella flavofasciata* Ulmer**

Leptocella flavofasciata Ulmer, 1907a, p. 18; 1907b, p. 138; 1913, p. 410.—Fischer, 1966, p. 55.—Flint, 1966, p. 9.

Leptocella sparsa Banks, 1920, p. 353.—Fischer, 1966, p. 60.—Flint, 1966, p. 9.

Lectotype, male: "Misiones Jørgensen I-11-1909," "N. Banks," "Type 10899," "*Leptocella sparsa* Bks. type."

The species was figured recently by Flint (1966).

***Leptocella gracilis* Banks**

FIGURE 101; PLATE 1H

Leptocella gracilis Banks, 1901, p. 369.—Ulmer, 1905b, p. 29; 1907b, p. 138; 1913, p. 410.—Betten, 1934, p. 267.—Fischer, 1966, p. 51.

Figure 101 of the genitalia was prepared from the holotype from Mexico. The eyes of the male are separated ventrally by twice the diameter of the eye.

***Leptocella pretiosella* (Banks), new combination**

Setodes pretiosella Banks, 1924, p. 447.—Fischer, 1966, p. 48.

The holotype, a female from Peru, is a member of the *L. pavida* group.

***Leptocella punctata* Ulmer**

Leptocella punctata Ulmer, 1905c, p. 75; 1907b, p. 138; 1913, pp. 402, 410.—

Fischer, 1966, p. 60.—Flint, 1966, p. 9.

Leptocella fenestrata Banks, 1913b, p. 237.—Betten, 1934, p. 267.—Fischer, 1966, p. 55.—Flint, 1966, p. 9.

The holotype male of *fenestrata* is from Panama. The species was illustrated by Flint in 1966.

***Leptocella separata* Banks**

FIGURE 103; PLATE 1G

Leptocella separata Banks, 1920, p. 353.—Fischer, 1966, p. 60.

Lectotype, male: "No. 12," "Type 10898," "*Leptocella separata* Bks. type."

The lectotype is from Brazil from Fritz Müller and bears his "number 12." The illustrations (figs. 103, pl. 1G) are from a specimen compared with, and found identical to, the type.

Genus *Leptocellodes* Ulmer***Leptocellodes pulchellus* (Banks)**

FIGURES 104, 105

Leptocella pulchella Banks, 1910, p. 160.—Ulmer, 1913, p. 410.—Fischer, 1966, p. 60.

Leptocellodes pulchellus (Banks).—Ulmer, 1955, p. 499.

Figures 104 and 105 were prepared from the male holotype from Columbia.

Genus *Oecetina* Banks

Oecetina amazonica Banks: See *Oecetis amazonica* (Banks).

Oecetina antillana Banks: See *Oecetis inconspicua* (Walker).

Oecetina parishii Banks: See *Oecetis punctipennis* (Ulmer).

Oecetina peruviana Banks: See *Oecetis peruviana* (Banks).

Genus *Oecetis* McLachlan***Oecetis amazonica* (Banks)**

FIGURES 106, 107

Oecetina amazonica Banks, 1924, p. 447.

Oecetis amazonica (Banks).—Fischer, 1966, p. 109.

Lectotype, male: "Manaos, Amazonas Brazil, Mann Coll." "Type 14830," "*Oecetina amazonica* Bks. type."

The figures were prepared from the male lectotype.

***Oecetis inconspicua* (Walker)**

Leptocerus inconspicuus Walker, 1852, p. 71.

Oecetis inconspicua (Walker).—Betten and Mosely, 1940, p. 67.—Fischer, 1966, p. 149.

Oecetina antillana Banks, 1938, p. 298. [New synonymy.]

Oecetis antillana (Banks).—Fischer, 1966, p. 109.

Lectotype, male: "Soledad, Cuba (Cienfuegos) Apr. 1936 23 Darlington," "Cuba 1936 Darlington Collector," "M.C.Z. Type 22670," "*Oecetina antillana* Bks. type."

The lectotype appears identical with the type of *inconspicua* as figured by Betten and Mosely (1940). Fischer (1966) gives a complete bibliography of this common species.

***Oecetis peruviana* (Banks)**

FIGURES 108, 109

Oecetina peruviana Banks, 1924, p. 446.

Oecetis peruviana (Banks).—Fischer, 1966, p. 139.

Lectotype, male: "Iquitos Peru 17 May Parish," "Type 14831," "*Oecetina peruviana* Bks. type."

Figures 108 and 109 were drawn from the lectotype.

***Oecetis punctipennis* (Ulmer)**

Pseudosetodes punctipennis Ulmer, 1905c, p. 77; 1907b, p. 147; 1913, p. 410.—Fischer, 1966, p. 104.

Oecetina parishii Banks, 1915, p. 631.—Mosely, 1931, p. 170.

Oecetis parishii (Banks).—Fischer, 1966, p. 139.—Flint, 1966, p. 10.

Oecetis punctipennis (Ulmer).—Flint, 1966, p. 10.

The genitalia were figured by Flint recently (1966).

Genus *Setodes* Rambur

Setodes pretiosella Banks: See *Leptocella pretiosella* (Banks).

LEPIDOSTOMATIDAE

Genus *Eremopsyche* Banks

Eremopsyche frontalis Banks: See *Lepidostoma frontalis* (Banks).

Genus *Lepidostoma* Rambur

(Genus *Eremopsyche* Banks, new synonymy)

The type and only species of *Eremopsyche*, *frontalis* Banks, clearly belongs to the genus *Lepidostoma* as it is presently recognized by North

American workers. I, therefore, synonymize *Eremopsyche* with *Lepidostoma* (new synonymy).

***Lepidostoma frontalis* (Banks), new combination**

FIGURES 124, 125

Eremopsyche frontalis Banks, 1901, p. 367.—Ulmer, 1907b, p. 110; 1913, p. 411.—Ross, 1946, p. 290.

Figures 124 and 125 of this Mexican species were prepared from the male holotype.

***Lepidostoma mexicana* (Banks)**

FIGURES 126, 127

Olemira mexicana Banks, 1901, p. 367.—Ulmer, 1907b, p. 109; 1913, p. 411. *Lepidostoma mexicana* (Banks).—Ross, 1946, p. 288.

Figures 126 and 127 were prepared from the female holotype, which is from Mexico.

Genus *Olemira* Banks

Olemira mexicana Banks: See *Lepidostoma mexicana* (Banks).

HELICOPSYCHIDAE

Genus *Helicopsyche* Siebold

***Helicopsyche hageni* Banks**

FIGURES 122, 123

Helicopsyche hageni Banks, 1938, p. 296.

Lectotype, male: "Pico Turquino N. side June 18–20, 1936 4500–6000 ft.," "Cuba 1936 Darlington Collector," "M.C.Z. Type 22668," "Helicopsyche hageni Bks. type."

Figures 122 and 123 here given are those of the lectotype.

***Helicopsyche haitiensis* Banks**

Helicopsyche haitiensis Banks, 1938, p. 296.—Ross, 1956b, p. 398.

Lectotype, male: "La Visite & vic. La Selle Range 5–7000 ft. Sept. 16–23," "Haiti 1934 M. Bates," "M.C.Z. Type 22106," "Helicopsyche haitiensis Bks. type."

The male genitalia were figured by Ross (1956b). The type agrees with the figures except that the apex of the clasper has a more prominent point than Ross's figure shows.

***Helicopsyche lutea* (Hagen)**

Notidobia lutea Hagen, 1861, p. 271; 1864, p. 853.—McLachlan, 1876, p. 238.—Kolbe, 1888, p. 167.—Ross, 1952, p. 35.

Helicopsyche lutca (Hagen).—Ulmer, 1907c, p. 94; 1913, p. 411.—Betten, 1934, p. 418.

The lectotype, designated by Ross, is a female. I have a male from Santo Domingo that agrees with the type in size and coloration. It appears to be the same as the one recently described by Kingsolver from Cuba as *H. comosa*; however, until a series of this species containing both males and females is available, I hesitate to establish the synonymy.

***Helicopsyche mexicana* Banks**

Helicopsyche mexicana Banks, 1901, p. 368.—Ulmer, 1907b, p. 94; 1913, p. 411.—Betten, 1934, p. 418.—Ross, 1944, p. 289.—Denning, 1964, p. 132.

Both Ross (1944) and Denning (1964) have figured the male genitalia of this species. It was described originally from a single male from Mexico.

***Helicopsyche muelleri* Banks**

Helicopsyche muelleri [sic] Banks, 1920, p. 348.—Marlier, 1964, p. 15.

Helicopsyche turbida Navas, 1923, p. 200.—Schmid, 1949, p. 419.—Marlier, 1964, p. 15. [New synonymy.]

Helicopsyche angelae Marlier, 1964, p. 9. [New synonymy.]

Lectotype, male: "Santa Catharina Brazil no. 18 F. Müller," "Type 10906," "*Helicopsyche muelleri* Bks. type."

It is with some hesitation that I synonymize these three species. The male genitalia of the type of *muelleri* and the figures of the genitalia of the types of *turbida* (Schmid, 1949) and *angelae* (Marlier, 1964) are identical. Both of the latter species, however, are stated to lack the process from the sixth sternum, which is clearly present in *muelleri*. Perhaps the spines are broken off in the types of *turbida* and *angelae*, or the presence or absence of the process may vary from one part of the range to another.

***Helicopsyche peruana* Banks**

Helicopsyche peruana Banks, 1920, p. 349.—Marlier, 1964, p. 15.

Helicopsyche woytkowskii Ross, 1956b, p. 398. [New synonymy.]

The figures (Ross, 1956b) of the type of *woytkowskii* are very similar to the holotype, male, of *peruana*. The only difference is that *peruana* has four small seta-bearing teeth along the dorsal margin that are not shown in Ross's figure. In spite of this, I believe the two are synonymous.

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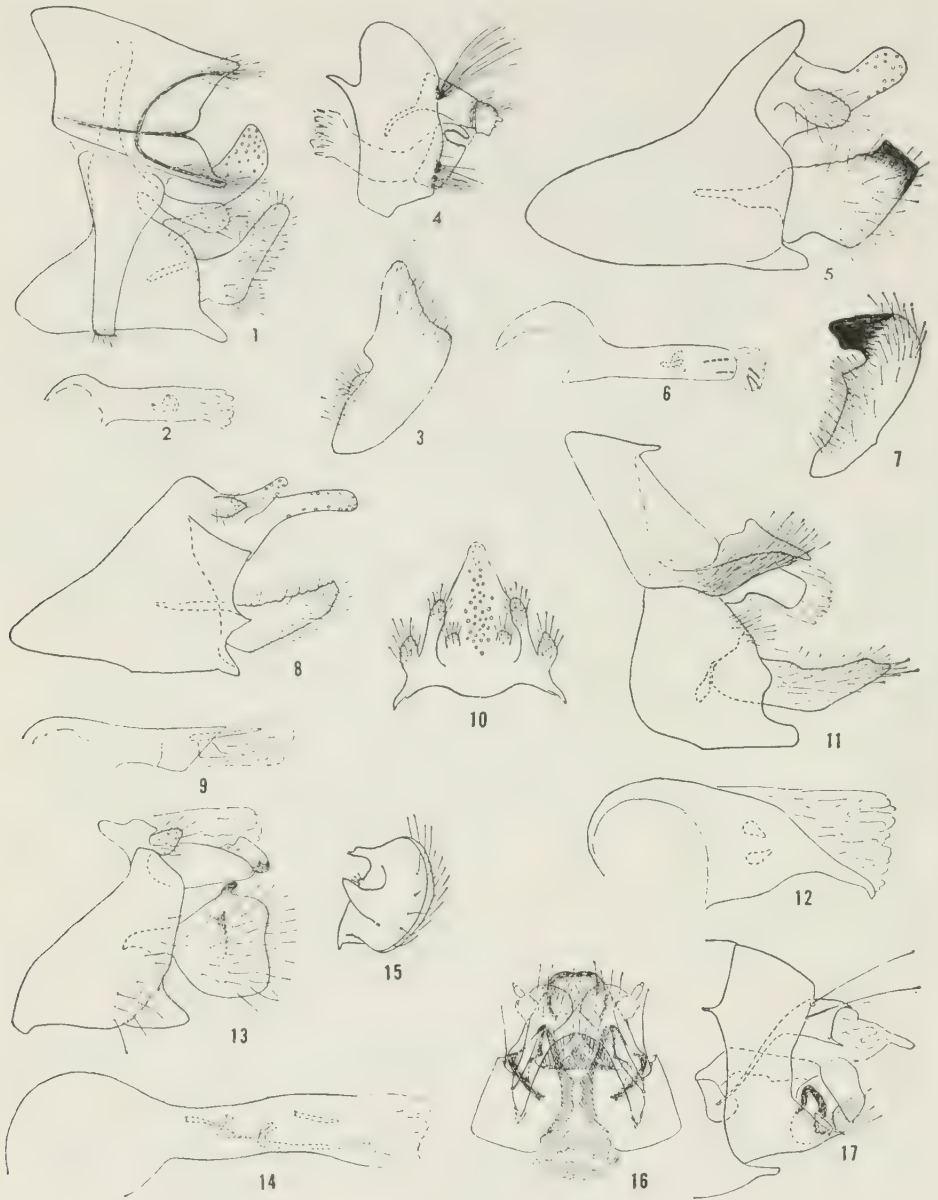
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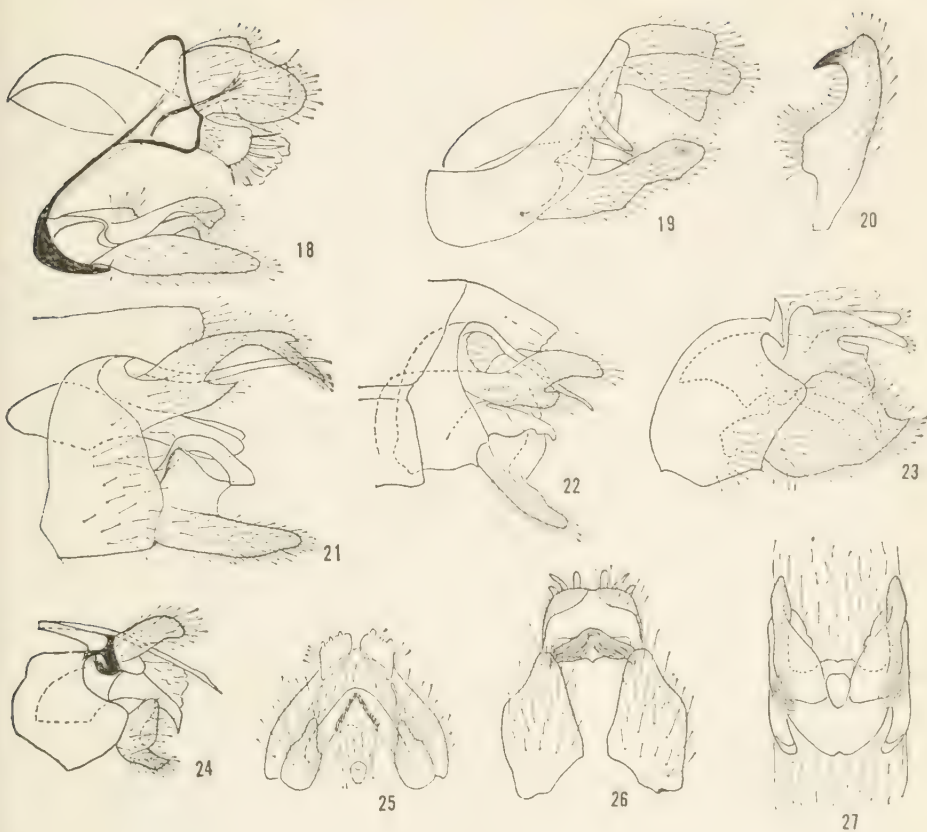
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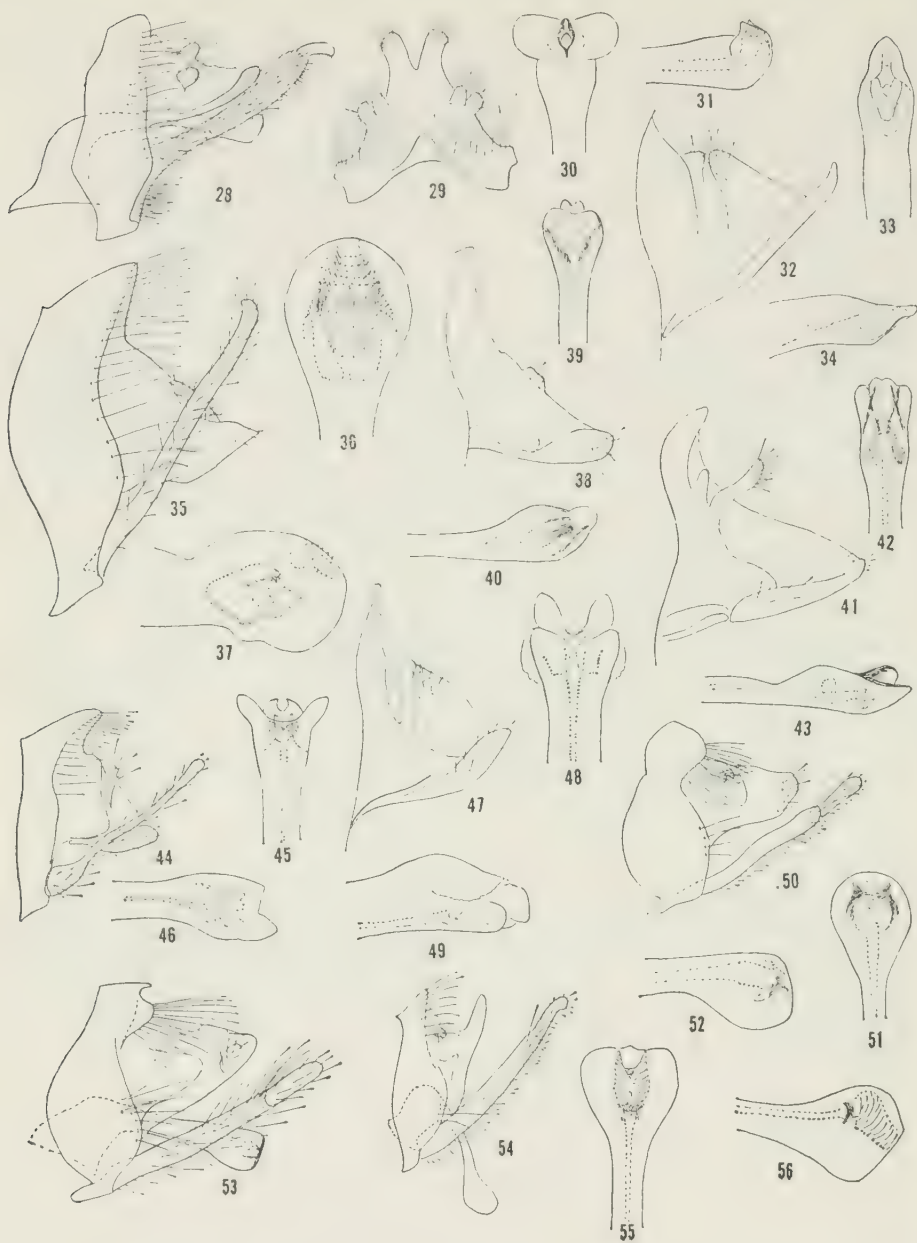
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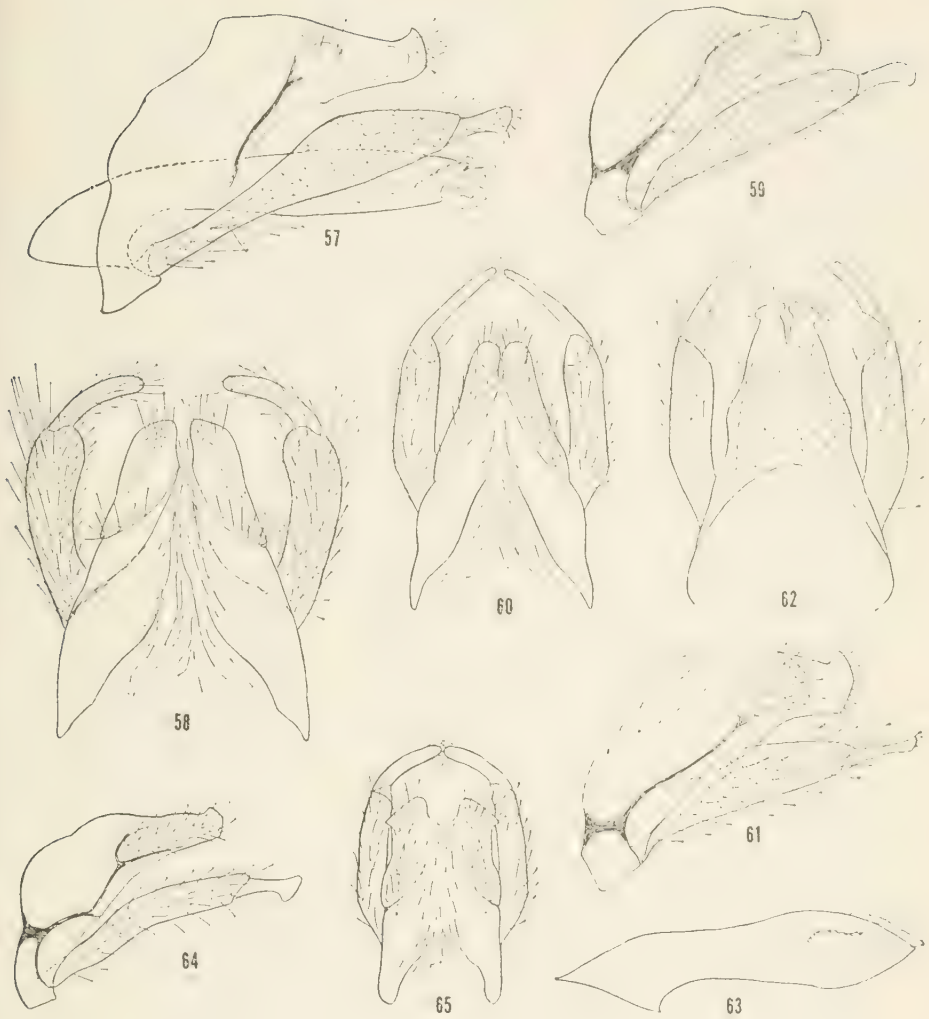
FIGURES 1-17.—*Chimarra banksi* (Ulm.): 1, genitalia, lateral; 2, aedeagus, lateral; 3, clasper, posteroventral. *C. mexicana* (Bks.): 4, female genitalia, lateral; 5, male genitalia, lateral; 6, aedeagus, lateral; 7, clasper posteroventral. *C. pulchra* (Hag.): 8, genitalia, lateral; 9, aedeagus, lateral; 10, tenth tergum, dorsal. *C. persimilis* (Bks.): 11, genitalia, lateral; 12, aedeagus, lateral. *C. bicolor* (Bks.): 13, genitalia, lateral; 14, aedeagus, lateral; 15, clasper, posterior. *C. moesta* (Bks.): 16, female genitalia, ventral. *C. pumila* (Bks.): 17, female genitalia, lateral.



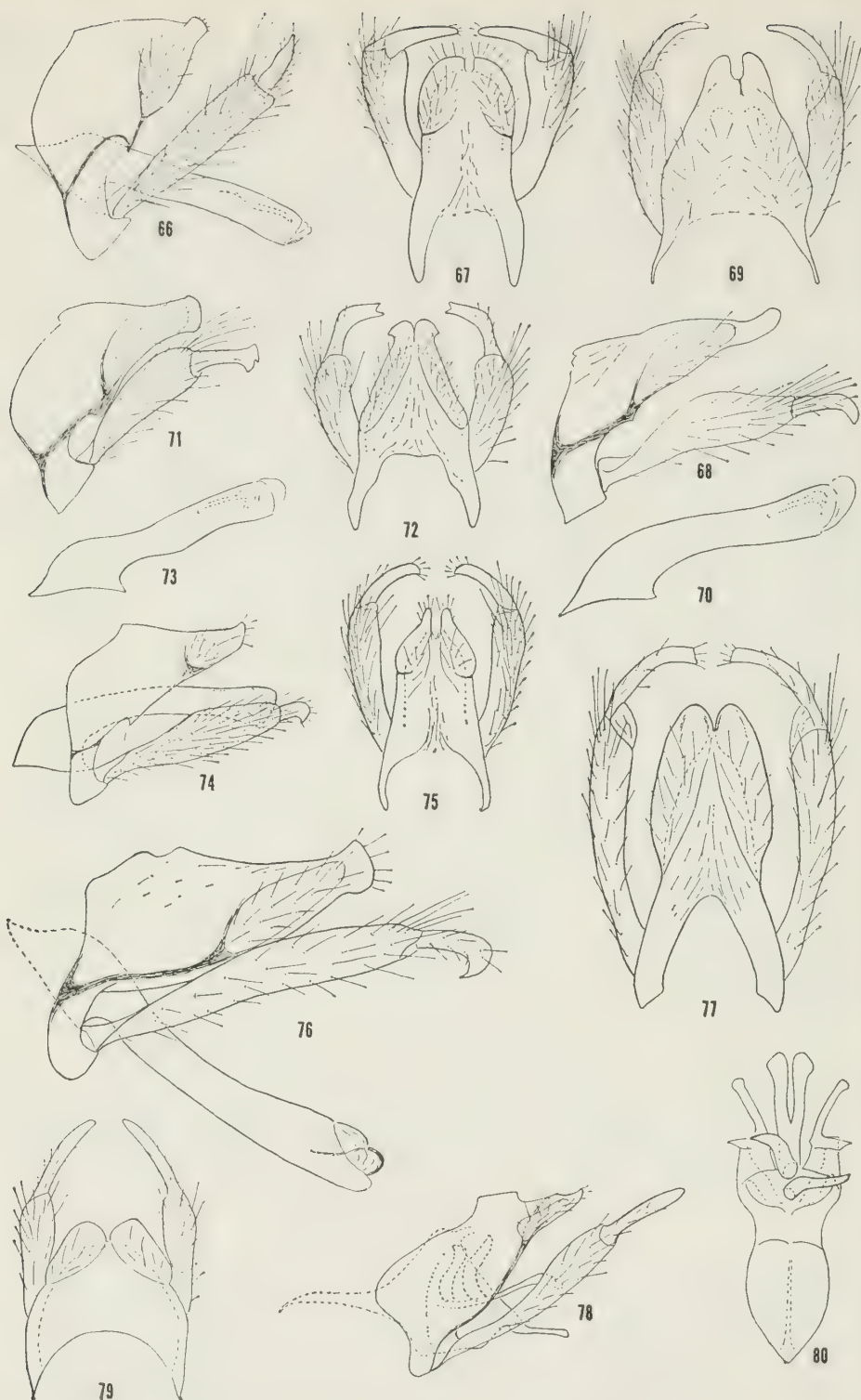
FIGURES 18-27.—*Antillopsyche wrighti* Bks.: 18, genitalia, lateral. *Crynellus minimus* Bks.: 19, genitalia, lateral; 20, clasper, ventral. *Polycentropus domingensis* Bks.: 21, genitalia, lateral. *P. nigriceps* Bks.: 22, genitalia, lateral. *P. mexicanus* (Bks.): 23, genitalia, lateral. *P. insularis* Bks.: 24, genitalia, lateral. *P. colombiensis* Bks.: 25, female genitalia, ventral. *Polypsectropus costalis* (Bks.): 26, female genitalia, ventral; 27, bursa copulatrix, ventral.



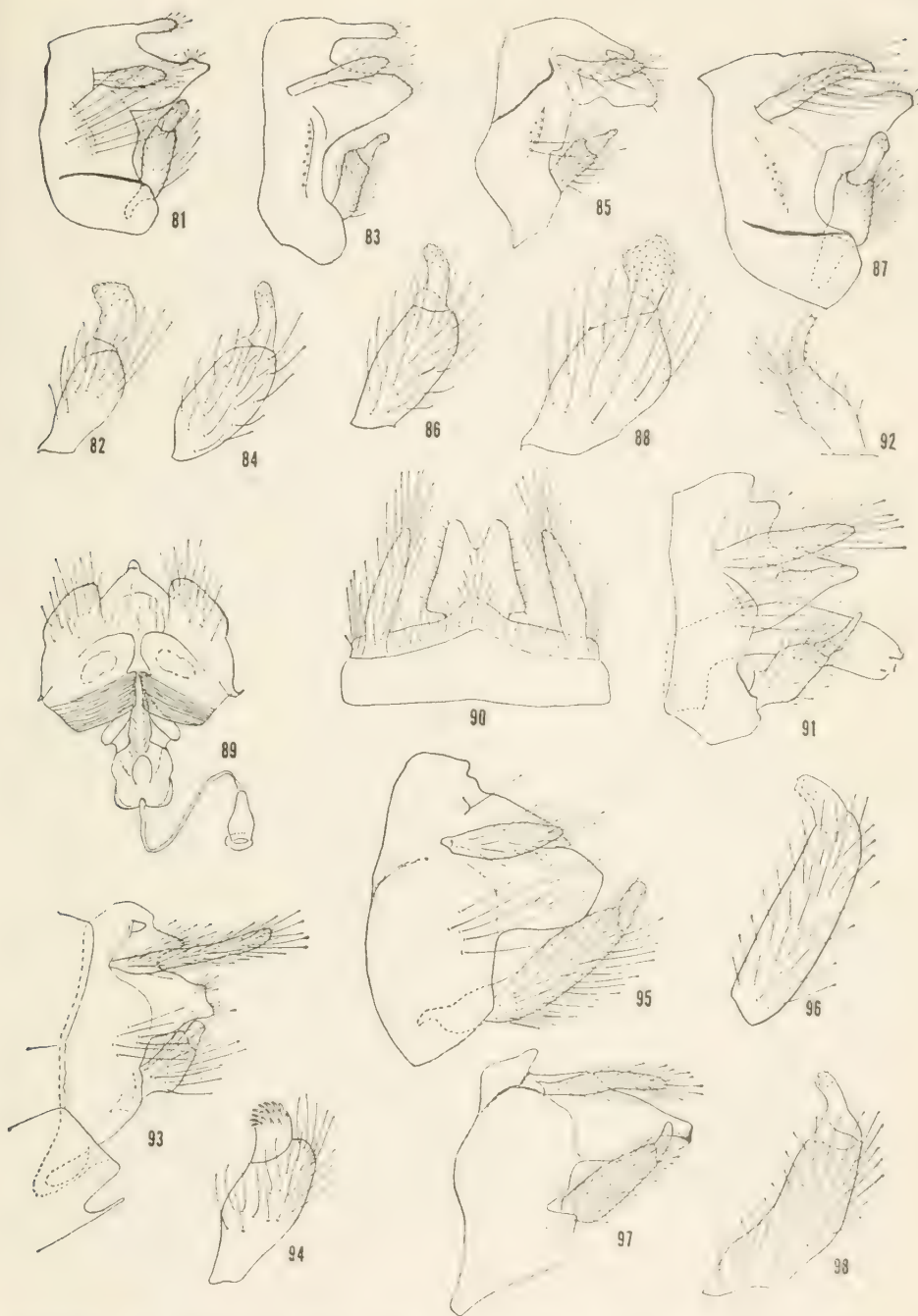
FIGURES 28-56. *Leptonema poeyi* (Bks.): 28, genitalia, lateral; 29, tenth tergum, dorsal; 30, tip of aedeagus, dorsal; 31, tip of aedeagus, lateral. *Macronema fraternum* Bks.: 32, tenth tergum, lateral; 33, tip of aedeagus, ventral; 34, tip of aedeagus, lateral. *M. gundlachi* Bks.: 35, genitalia, lateral; 36, tip of aedeagus, dorsal; 37, tip of aedeagus, lateral. *M. muelleri* Bks.: 38, tenth tergum, lateral; 39, tip of aedeagus, ventral; 40, tip of aedeagus, lateral. *M. fragilis* Bks.: 41, tenth tergum, lateral; 42, tip of aedeagus, ventral; 43, tip of aedeagus, lateral. *M. lachlani* Bks.: 44, genitalia, lateral; 45, tip of aedeagus, ventral; 46, tip of aedeagus, lateral. *M. hageni* Bks.: 47, tenth tergum, lateral; 48, tip of aedeagus, ventral; 49, tip of aedeagus, lateral. *M. subaequalis* Bks.: 50, genitalia, lateral; 51, tip of aedeagus, ventral; 52, tip of aedeagus, lateral. *M. ulmeri* Bks.: 53, genitalia, lateral. *Plectromacronema subfuscum* (Bks.): 54, genitalia, lateral; 55, tip of aedeagus, ventral; 56, tip of aedeagus, lateral.



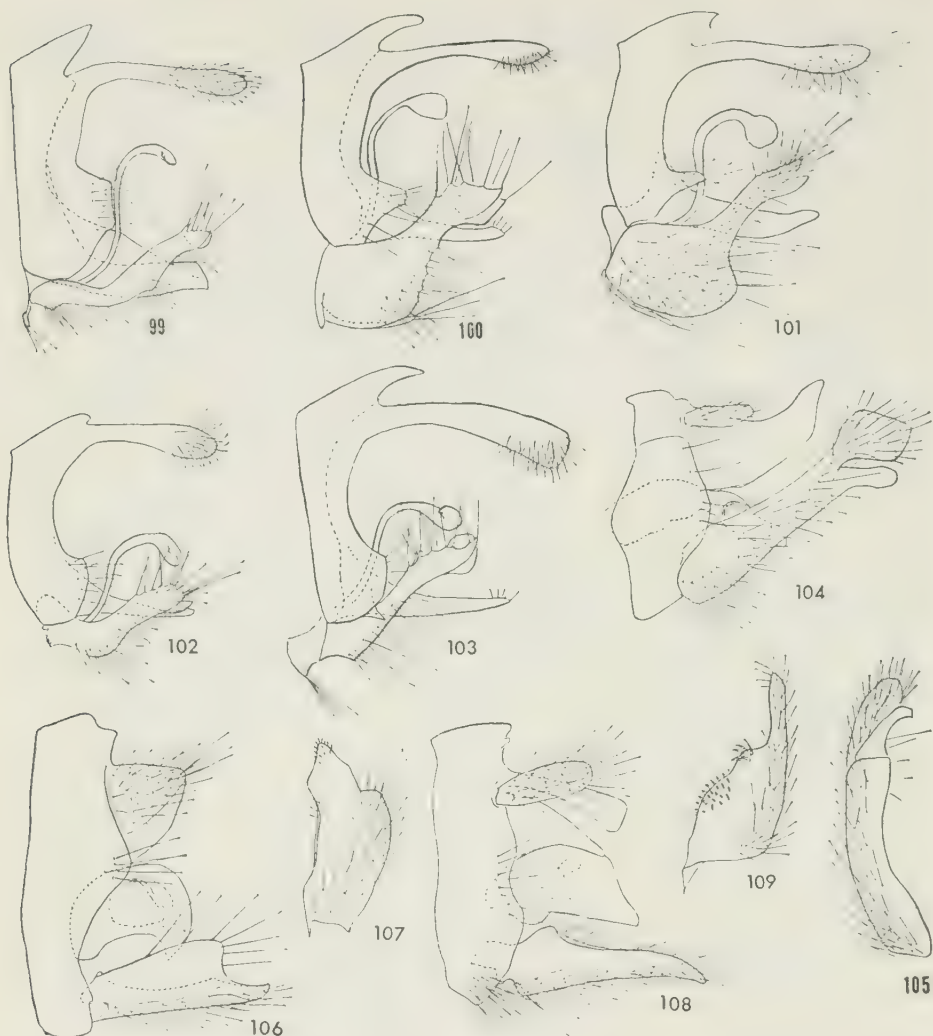
FIGURES 57-65.—*Smicridea obesa* Bks.: 57, genitalia, lateral; 58, genitalia, dorsal. *S. comma* Bks.: 59, genitalia, lateral; 60, genitalia, dorsal. *S. banksi* Flint: 61, genitalia, lateral; 62, genitalia, dorsal; 63, aedeagus, lateral. *S. completa* Bks.: 64, genitalia, lateral; 65, genitalia, dorsal.



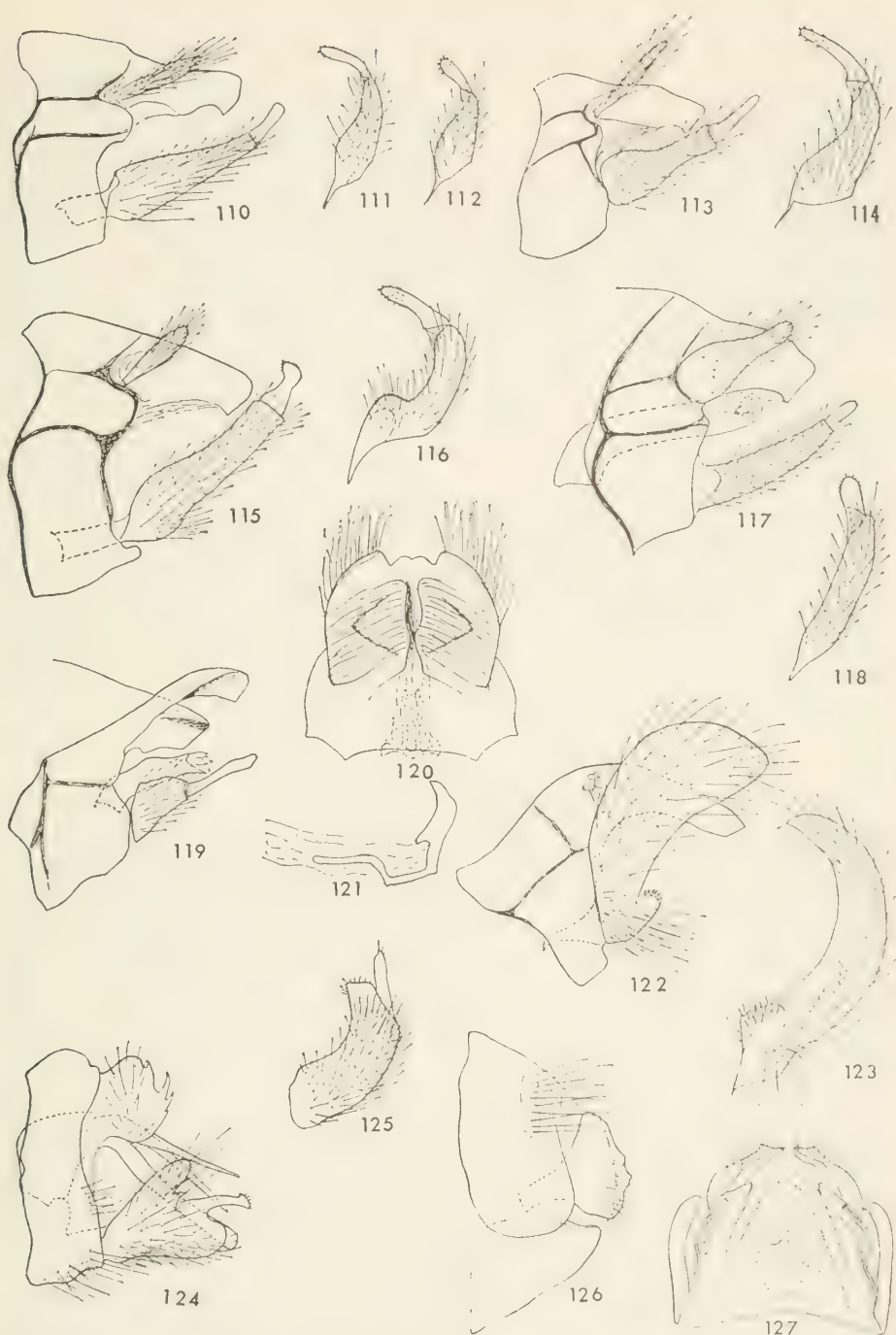
FIGURES 66-80.—*Smicridea unicolor* (Bks.): 66, genitalia, lateral; 67, genitalia, dorsal. *S. varius* (Bks.): 68, genitalia, lateral; 69, genitalia, dorsal; 70, aedeagus, lateral. *S. bivittata* (Hag.): 71, genitalia, lateral; 72, genitalia, dorsal; 73, aedeagus, lateral. *S. aequalis* Bks.: 74, genitalia, lateral; 75, genitalia, dorsal. *S. albosignata* Ulm.: 76, genitalia, lateral; 77, genitalia, dorsal. *S. nigripennis* Bks.: 78, genitalia, lateral; 79, genitalia, dorsal; 80, aedeagus, dorsal.



FIGURES 81-98.—*Phylloicus cubanus* Bks.: 81, genitalia, lateral; 82, clasper, posterior, *P. chalybeus* (Hag.): 83, genitalia, lateral; 84, clasper, posterior. *P. iridescent* Bks.: 85, genitalia, lateral; 86, clasper, posterior. *P. superb* Bks.: 87, genitalia, lateral; 88, clasper, posterior. *P. maculatus* (Bks.): 89, female genitalia, ventral. *P. aeneus* (Hag.): 90, genitalia, dorsal; 91, genitalia, lateral; 92, clasper, posterior. *P. lituratus* Bks.: 93, genitalia, lateral; 94, clasper, posterior. *P. magnus* Bks.: 95, genitalia, lateral; 96, clasper, posterior. *P. brevior* Bks.: 97, genitalia, lateral; 98, clasper, posterior.



FIGURES 99-109.—*Leptocella cubana* Bks.: 99, genitalia, lateral. *L. dorsalis* Bks.: 100, genitalia, lateral. *L. gracilis* Bks.: 101, genitalia, lateral. *L. diminuta* Bks.: 102, genitalia, lateral. *L. separata* Bks.: 103, genitalia, lateral. *Leptocellodes pulchellus* (Bks.): 104, genitalia, lateral; 105, clasper, posterior. *Oecetis amazonica* (Bks.): 106, genitalia, lateral; 107, clasper, ventral. *O. peruviana* (Bks.): 108, genitalia, lateral; 109, clasper, ventral.



FIGURES 110-127.—*Marilia gracilis* Bks.: 110, genitalia, lateral; 111, clasper, posterior. *M. gracilis nigrescens* Bks.: 112, clasper, posterior. *M. scudleri* Bks.: 113, genitalia, lateral; 114, clasper, posterior. *M. wrighti* Bks.: 115, genitalia, lateral; 116, clasper, posterior. *M. modesta* Bks.: 117, genitalia, lateral; 118, clasper, posterior. *M. fasciculata* Bks.: 119, genitalia, lateral. *M. mexicana* (Bks.): 120, female genitalia, ventral; 121, bursa copulatrix, lateral. *Helicopsyche hageni* Bks.: 122, genitalia, lateral; 123, clasper, posterior. *Lepidostoma frontalis* (Bks.): 124, genitalia, lateral; 125, clasper, ventral. *L. mexicana* (Bks.): 126, female genitalia, lateral; 127, female genitalia, ventral.



FIGURES A-H.—A, *Macronema picteti* Bks.; B, *M. hayeni* Bks.; C, *M. fraternum* Bks.; D, *M. ulmeri* Bks.; E, *Plectromacronema subfuscum* (Bks.); F, *Macronema erichsoni* Bks.; G, *Leptocella separata* Bks.; H, *L. gracilis* Bks.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3620

Neotropical Microlepidoptera, XV¹

Review of Genus *Thioscelis* (Lepidoptera: Stenomidae)

By W. Donald Duckworth

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This paper represents part of a continuing study of the Neotropical moths of the family Stenomidae and presents for the first time, since the genus *Thioscelis* Meyrick was established in 1909, illustrations, descriptions, distributions, and keys to all the known species. In addition, during the course of the study, three new species were encountered and are described herein.

¹ Prepared with the aid of a National Science Foundation Grant. Previous parts of this same series are: I and II, Clarke, 1962, Proc. U.S. Nat. Mus., vol. 113, no. 3457, pp. 373-388; III, Clarke, 1964, *ibid.*, vol. 115, no. 3480, pp. 61-84; IV, Duckworth, 1964, *ibid.*, vol. 116, no. 3497, pp. 97-114; V, Obraztsov, 1964, *ibid.*, vol. 116, no. 3501, pp. 183-196; VI, Clarke, 1964, *ibid.*, vol. 116, no. 3502, pp. 197-204; VII, Obraztsov, 1966, *ibid.*, vol. 118, no. 3527, pp. 221-232; VIII, Duckworth, 1966, *ibid.*, vol. 118, no. 3531, pp. 391-404; IX, Obraztsov, 1966, *ibid.*, vol. 118, no. 3535, pp. 577-622; X, Duckworth, 1966, *ibid.*, vol. 119, no. 3540, pp. 1-6; XI, Obraztsov, 1966, *ibid.*, vol. 119, no. 3543, pp. 1-12; XII, Duckworth, 1967, *ibid.*, vol. 122, no. 3585, pp. 1-38; XIII, Duckworth, 1967, *ibid.*, vol. 122, no. 3590, pp. 1-8; XIV, Clarke, 1967, *ibid.*, vol. 122, no. 3591, pp. 1-8.

Although the moths composing the genus *Thioscelis* are among the largest and most striking in the family Stenomidae, they are relatively rare in collections. Thus, the distributional data presented is fragmentary and, at best, merely reflects the state of current knowledge concerning the genus. Certainly a great deal more collecting must be done before any reasonable speculations can be made concerning the zoogeography of the group. Also, host plant records and other life cycle data are completely lacking at this time, emphasizing once again the critical need for increased field activity in the Neotropics.

The author wishes to acknowledge with thanks the cooperation and aid of the following persons who have allowed him to study the types and specimens in their charge: Mr. P. E. S. Whalley and Mr. Allan Watson of the British Museum (Natural History); Dr. J. G. Franclemont of Cornell University; and Dr. Fritz Kasy of the Naturhistorisches Museum, Vienna.

The author also wishes to acknowledge the assistance of Mrs. Sandra Duckworth in all phases of the study. The map and line drawings were prepared by Mr. André Pizzini and the photographs by Mr. Jack Scott.

Work on this paper was aided in part by the National Science Foundation on Grant GB-1800.

History

The genus *Thioscelis* was described by Meyrick (1909, p. 29) for a new species, *T. directrix*, that he described from two specimens collected in Peru. Walsingham (1912, p. 153) listed the genus for Central America based on a specimen from Costa Rica in the U.S. National Museum determined by A. Busck as *T. directrix*. Meyrick (1932, p. 287) described a second species, *T. geranomorpha*, from Brazil. Busck (1934, p. 6) listed *Thioscelis* and the two described species in the Stenomidae part of the "Lepidopterorum Catalogus" series. Clarke (1955, pp. 380-381) selected a lectotype and illustrated the wings and male genitalia of *T. directrix* in his study of the Meyrick types in the British Museum (Natural History).

Genus *Thioscelis* Meyrick

Thioscelis Meyrick, 1909, p. 29.

Type-species: *Thioscelis directrix* Meyrick, by monotypy.

Head rough, lateral tufts spreading. Labial palpus long, recurved, extending above head; second segment with appressed scales; apical segment acute at apex, slightly shorter than second. Foreleg short, tibia much dilated with dense scales; midleg normal, tibia covered

with dense scales; hindleg greatly elongated, tibia very long, densely scaled dorsally and ventrally, tarsus longer than tibia, thickened with dense scales dorsally, tufted toward apex. Forewing with costa arched at base, straight beyond, apex square, termen straight, tornus rounded; with 12 veins, 2-5 approximate at base, 6-9 approximate at base, 7 to termen, 11 from middle of cell. Hindwing broader than forewing; with 8 veins, 3 and 4 connate, 5 approximate to 3 and 4, 6 and 7 approximate at base.

Male genitalia: Uncus long, somewhat recurved; gnathos complete, apex acute, hooklike; subscaphium absent; harpe with variously shaped ampulla clothed with short, heavy spines, furcate setae present; anellus large, sheathlike, with two digitate, setiferous lateral lobes; aedeagus simple, cornuti absent.

Female genitalia: Ostium bursae sclerotized; ductus bursae membranous; inception of ductus seminalis near ostium; corpus bursae membranous, with signum a small, lightly sclerotized spot.

This genus is recognized easily owing to the large size of the moths that compose it and the extreme development of their hindlegs. Meyrick (1909, p. 30) first noted the unusual hindleg length in his remarks on *T. directrix*: "A singular insect; the actual length of posterior leg is, femur 3 mm., tibia 14 mm., tarsus 24 mm.; total 41 mm." Inasmuch as biological data is lacking completely for this genus, it is impossible to determine the function or value of such long and seemingly awkward legs at this time. It is hoped that this publication and others, either published or to be published, on the genera composing the family Stenomidae will stimulate workers in Latin America to conduct biological studies that will help elucidate such problems.

The possibility that the legs of the moths in this genus might provide characters useful at the specific level was investigated during the course of this study. The results achieved were not conclusive owing primarily to the lack of sufficient numbers of specimens with intact legs. The great length of the hindlegs, three times the length of the abdomen in some species, results in frequent breakage or complete loss by handling, shipping, etc. As a result, the data gathered are considered to be too incomplete for presentation at this time.

The genitalia provide a number of distinguishing characters for the genus. The most outstanding male character is the development of a prominent ampulla bearing short, heavy setae. The size and shape of this ampulla varies among the species and provides reliable characters for their recognition. Because the female of only one species, *T. granomorpha*, is known, it is impossible to determine the characters of generic significance in the female genitalia.

Key to Species of *Thioscelis*

BASED ON MACULATION

1. Hindwing ochreous shaded with gray 2
Hindwing dark brown to black 4
2. Forewing with subterminal line a series of black dots; with two black spots at apex 3
Forewing with subterminal line a solid black line; without spots at apex. *T. lipara*, new species
3. Forewing with subterminal line with strong outward arch. *T. directrix* Meyrick
Forewing with subterminal line with only a slight outward arch. *T. whalleyi*, new species
4. Forewing light brown; subterminal line a solid black line. *T. geranomorphia* Meyrick
Forewing dark brown; subterminal line a faint series of black dots. *T. fuscata*, new species

BASED ON MALE GENITALIA

1. Ampulla rounded at apex; apex of gnathos slender 3
Ampulla acute at apex, falciform; apex of gnathos broad. *T. lipara*, new species
2. Harpe with apical region longer than ampulla 4
Harpe with apical region equal or slightly longer than ampulla; ampulla large, clublike with tendency for slight counterclockwise twist at apical half *T. directrix* Meyrick
3. Ampulla slender, digitate *T. fuscata*, new species
Ampulla broad, expanded basally *T. whalleyi*, new species

Thioscelis directrix Meyrick

FIGURES 1, 2, 5, 6; PLATE 1 (FIG. 1); MAP 1

Thioscelis directrix Meyrick, 1909, p. 30.

Alar expanse 54–63 mm.

Antenna dark brown. Head light brown; second segment of labial palpus black externally on basal half, apical segment dark brown anteriorly. Legs light brown, femora white, midtibia white, yellow above toward base, hind tibia yellow orange dorsally, white ventrally, separated by a dark brown lateral line, mid- and hind tarsi dark brown to black. Thorax light brown dorsally, white ventrally. Abdomen yellow dorsally, white ventrally. Forewing light brown, paler and whitish tinged at base of costa; costal edge ochreous basally, dark brown beyond; an area of ill-defined black spots on median third near costa; outwardly curving transverse subterminal line of black dots from costa to dorsum; two ill-defined black spots at apex; a terminal line of black dots from apex to dorsum. Cilia ochreous, shaded with brown from midtermen to apex. Hindwing ochreous heavily overlaid with gray. Cilia ochreous tinged with yellow orange.

Male genitalia (slide WDD 3661): Uncus slightly recurved, somewhat concave ventrally, apex variable, generally with slight notch but

occasionally may be forked; apex of gnathos slender, acute; harpe with apical region equal or slightly longer than ampulla, ampulla large, clublike with tendency for slight counterclockwise twist at apical half.

Female genitalia: Unknown.

Type: In the British Museum (Natural History).

Type-locality: El Porvenir, Peru.

Distribution: PERU: El Porvenir, south Peru, 3300 ft. (no date); Sani Beni, Lima (August); north Peru (no date); Peru (no date); Huancabamba, east Peru, 6000–10,000 ft. (no date). BOLIVIA: Chimate, 760 m. (September). COSTA RICA: Tuis (May, June).

This species is recognized easily by the large clublike ampulla in the male genitalia. In maculation it is very similar to the following species *T. whalleyi*, the principle difference being the more pronounced outward curvature of the subterminal line on the forewing.

Walsingham (1912, p. 153) listed *T. directrix* as occurring in Central America on the basis of a specimen in the U.S. National Museum determined by A. Busck. Meyrick (1932, p. 288) questioned this record, stating: "Walsingham (Biol. C.-Am. iv, 153) records *T. directrix* from Costa Rica, on the authority of Mr. Busck; it is more probable geographically that the species intended is *geranomorpha*." I have studied the specimen in question and compared it with the types of both *T. directrix* and *T. geranomorpha* and find that Busck's determination was correct. The distribution pattern this produces is not uncommon in the family and actually is more feasible geographically than that suggested by Meyrick.

Thioscelis whalleyi, new species

FIGURES 4, 7, 8; PLATE 1 (FIG. 2); MAP 1

Alar expanse 50–52 mm.

Antenna, head, legs, thorax, and abdomen as for *T. directrix*. Forewing as in *T. directrix* except subterminal line straighter, arising nearer apex on costa. Hindwing as for *T. directrix*.

Male genitalia (slide WDD 3660, paratype): Uncus slightly re-curved, somewhat expanded at apex; gnathos as for *T. directrix*; harpe with apical region longer than ampulla, ampulla short, expanded basally on ventral margin.

Female genitalia: Unknown.

Type: In the United States National Museum, no. 69513.

Type-locality: Campo Bello Rio, Brazil.

Distribution: BRAZIL: Campo Bello Rio, Goiaz (January); Rio de Janeiro (January).

Described from the male holotype: "No. 9, Campo Bello Rio, Brazil, Jan. 30, 1929"; one male paratype: "No. 9, Campo Bello Rio,

Brazil, Jan. 10, 1931"; three male paratypes: "(J. F. Ziran), No. 9, Rio de Janeiro, 31-1-29, 1-3-27, 28-1-30."

The species is related closely to the preceeding one, *T. directrix*; however, the short ampulla expanded basally in the male genitalia serves to distinguish *T. whalleyi* from all other species.

The maculation distinction between the two species was described in the remarks on *T. directrix*.

I take great pleasure in naming this species for my friend and colleague Mr. P. E. S. Whalley, lepidopterist at the British Museum (Natural History), who has been of great aid in my study of the family Stenomidae.

Thioscelis lipara, new species

FIGURES 9, 10; PLATE 1 (FIG. 3); MAP 1

Alar expanse 53 mm.

Antenna light brown. Head as for *T. directrix*. Legs as in *T. directrix* except hind tibia with less pronounced dark brown lateral line. Thorax and abdomen as for *T. directrix*. Forewing ochreous, overlaid with light brown; a small, distinct S-shaped black spot on median third near costa surrounded by a small patch of ill-defined black dots; transverse subterminal and terminal lines complete rather than composed of dots as in previous two species, only slightly curved. Cilia ochreous. Hindwing ochreous lightly overlaid with gray. Cilia ochreous.

Male genitalia (slide WDD 3658, type): Uncus recurved, swollen at apex, with distinct apical groove; apex of gnathos broad, acute; harpe with apical region equal to or slightly shorter than ampulla, ampulla falciform, outwardly curved.

Female genitalia: Unknown.

Type: In the British Museum (Natural History).

Type-locality: Fonte Boa, Amazonas, Brazil.

Distribution: Known only from the type-locality.

Described from the male holotype (S. M. Klages), Fonte Boa, Amazonas, May 1906.

This species is distinguished easily by the falciform ampulla and broad apex of the gnathos in the male genitalia. On maculation it differs in having a small, distinct S-shaped black spot on the median third of the forewing near the costa.

Thioscelis geranomorpha Meyrick

FIGURE 3; PLATE 1 (FIG. 4); MAP 1

Thioscelis geranomorpha Meyrick, 1932, p. 287.

Alar expanse 55-60 mm.

Antenna light brown, becoming darker apically. Head light brown, face whitish; second segment of labial palpus light brown with dark



Left wings: 1, *T. directrix* Meyrick; 2, *T. whalleyi*, new species; 3, *T. lipara*, new species; 4, *T. geranomorpha* Meyrick; 5, *T. fuscata*, new species.

brown scaling basally, apical segment dark brown. Legs as for *T. directrix*. Thorax light brown. Abdomen yellow dorsally, base of segments 2-4 irregularly gray; white ventrally. Forewing narrower apically than for *T. directrix*, apex rectangular; light brown irregularly shaded with darker scaling, maculation as for *T. directrix* except subterminal and terminal transverse lines solid, irregular black shading at apex. Cilia light brown. Hindwings dark brown to black. Cilia light brown with a dark brown median shade.

Male genitalia: Unknown.

Female genitalia (slide WDD 3325, type): Lamella antevaginalis broadly notched on posterior margin; lamella postvaginalis with deep median groove.

Type: In the Naturhistorisches Museum, Vienna, Austria.

Type-locality: Petropolis, Brazil.

Distribution: BRAZIL: Petropolis (March); São Paulo (March).

This species is separated readily from all others in the genus on the basis of wing shape and maculation. The subterminal line on the forewing is solid, and the apex is much more rectangular than in the other species. Since the females of the other species are not known, it is impossible to compare the characters found in the genitalia.

Thioscelis fuscata, new species

FIGURES 11, 12; PLATE 1 (FIG. 5); MAP 1

Alar expanse 46 mm.

Antenna light brown basally, dark brown beyond. Head, legs as for *T. directrix*. Thorax dark brown dorsally, tegula lighter. Abdomen as for *T. directrix*. Forewing dark brown, lighter on costa basally, median third with ill-defined black spotting; subterminal transverse line a faint series of black dots; terminal line barely distinguishable. Cilia dark brown, somewhat lighter basally. Hindwing dark brown to black. Cilia as for forewing.

Male genitalia (slide WDD 3566, type): Uncus short, recurved, enlarged at apex; apex of gnathos slender at apex, acute; harpe with apex much longer than ampulla; ampulla small, slender, digitate.

Female genitalia: Unknown.

Type: In the British Museum (Natural History).

Type-locality: La Oroya, Rio Inambari, Junín, 3100 ft., Peru.

Distribution: Known only from the type-locality.

Described from the male holotype (G. Ockenden), La Oroya, R. Inambari, Peru, September 1904, 3100 ft., dry seas.

The small, slender, digitate ampulla in the male genitalia readily distinguishes this species from all others in the genus.

The dark brown fore- and hindwings is the most distinctive superficial character.

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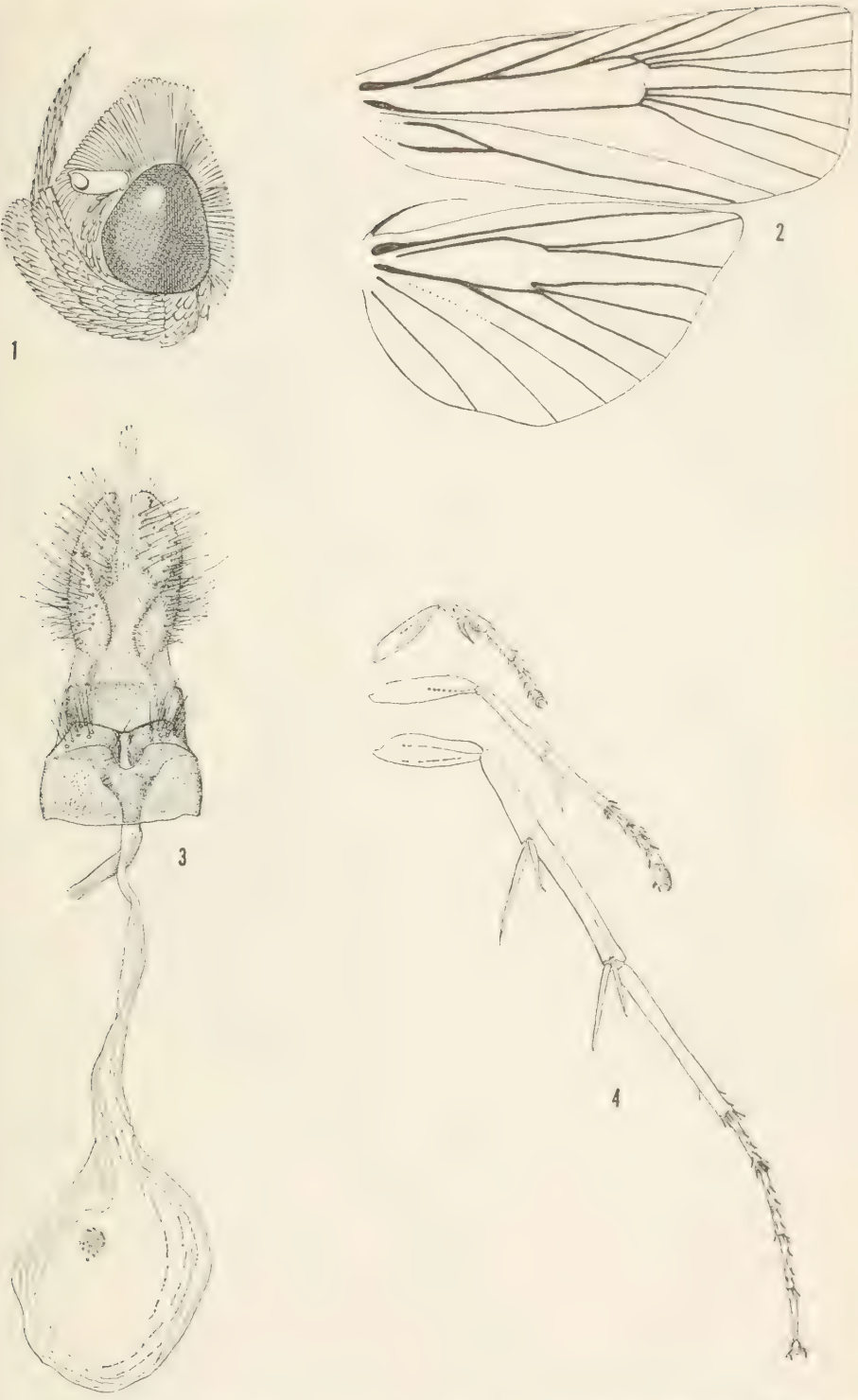
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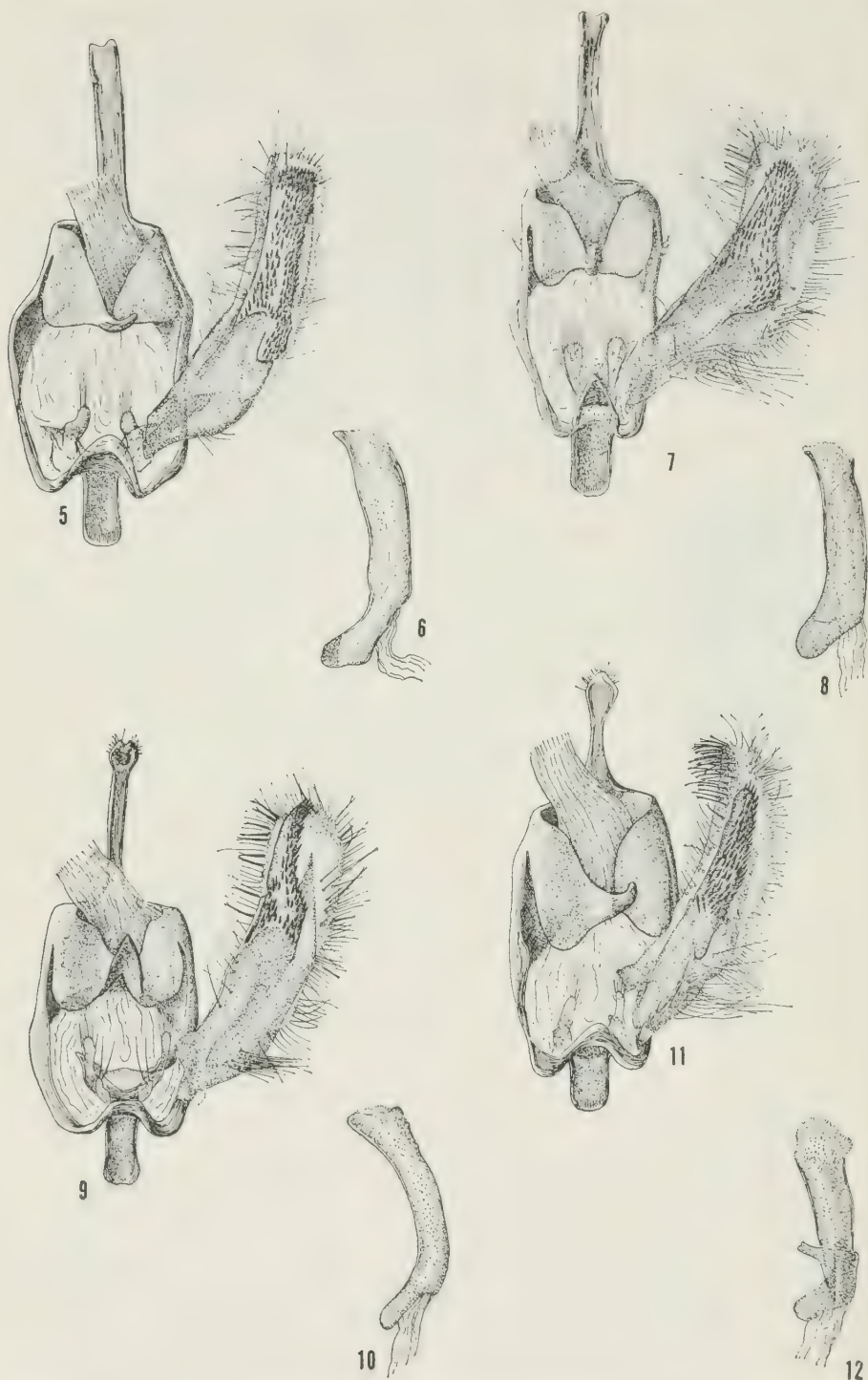
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FIGURES 1-4.—*T. directrix* Meyrick: 1, lateral view of head; 2, wing venation. *T. geranomorpha* Meyrick: 3, ventral view of female genitalia. *T. whalleyi*, new species: 4, legs (scales removed).



FIGURES 5-12.—Ventral view of male genitalia (aedeagus removed): 5, *T. directrix* Meyrick; 7, *T. whalleyi*, new species; 9, *T. lipara*, new species; 11, *T. fuscata*, new species. Aedeagus: 6, *T. directrix* Meyrick; 8, *T. whalleyi*, new species; 10, *T. lipara*, new species; 12, *T. fuscata*, new species.



Map 1.—Distribution of species.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3621

A New Crayfish from Alabama Caves with Notes on the Origin of the Genera *Orconectes* and *Cambarus* (Decapoda: Astacidae)

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The discovery of the new species described herein represents, from a phylogenetic standpoint, one of the most significant finds in the history of crayfish studies in the United States. With the knowledge of the occurrence of this remarkable crayfish in caves in northern Alabama, the initial postulate of Ortmann (1905a, p. 107) that the genus *Orconectes* (=Ortmann's subgenus *Faxonius*) was derived from a stock of the genus *Procambarus* (=Ortmann's subgenus *Cambarus*) now becomes more firmly fixed. In addition, there is more concrete evidence for postulating the places of origin for the *Orconectes* and *Cambarus* stocks, and, indirectly, for limiting the possible time of their origins.

I should like to express my appreciation to Mr. W. S. Peek, who collected the first specimens of this new species, and to Mr. and Mrs. John E. Cooper, who have added a third locality and a number of specimens from the type-locality. All three of them have generously donated specimens to the Smithsonian and have furnished me with data on the three localities from which the crayfishes were collected.

Genus *Procambarus* Ortmann

Procambarus Ortmann, 1905b, p. 437.

DIAGNOSIS.—First pleopod of first form male symmetrical or asymmetrical and terminating in from two to five distinct parts, which may be truncate, platelike, or spiniform; shoulder present or absent on cephalic surface; if pleopods terminate in two parts, shoulder always present some distance proximal to base of central projection. Hooks present on ischia of third or fourth pereopods, or both. Third maxillipeds not conspicuously elongate and with row of teeth on mesial margin of ischium. (Slightly modified from Hobbs, 1942, p. 342).

Procambarus pecki, new species

DIAGNOSIS.—Albinistic, eyes reduced and without pigment; rostrum with subparallel or slightly convergent margins and with marginal spines at base of acumen; postorbital ridges terminating cephalically in spines; areola 5.2 to 6.4 times longer than broad with three or four punctations across narrowest part and constituting 38.3 to 43.2 percent of total length of carapace; one to three cervical spines present on each side of carapace. Simple hooks present on ischia of third pereopods of male. First pleopods of first form male symmetrical, reaching coxae of third pereopods, with distinct shoulder on cephalic surface proximal to base of central projection; mesial process heavy, noncorneous, extending anterodistally considerably beyond apex of central projection and somewhat enveloping base of latter, distal end rounded; central projection slender, corneous, acute, and directed cephalodistally at angle of approximately 55 degrees to main shaft of appendage. Annulus ventralis somewhat globose but with shallow longitudinal median trough and very short, caudally situated, arelike sinus; proannular plate absent.

HOLOTYPE MALE, FORM I.—Albinistic, eyes reduced. Body subcylindrical, only slightly depressed. Abdomen narrower than thorax (7.8 and 8.8 mm in widest parts, respectively). Carapace wider than high in region of caudodorsal margin of cervical groove (8.8 and 7.3 mm); carapace widest slightly cephalic to midlength of areola.

Areola (fig. 3) moderately broad, 6.4 times longer than wide, with three or four punctations across narrowest part. Cephalic section of carapace 1.4 times longer than areola; length of areola 41.7 percent of entire length of carapace. Rostrum with nonthickened elevated convergent margins interrupted at base of acumen by long marginal spines reaching midlength of penultimate podomere of peduncle of antennule; acumen long and terminating apically in acute corneous spine reaching base of flagellum of antenna and beyond distal podo-

mere of peduncle of antennule; upper surface concave with scattered punctations and shallow fovea at base; rows of setiferous punctations mesial and lateral to margins, lateral row terminating cephalically at base of acumen and mesial row continuing onto acumen. Subrostral ridges moderately well developed and evident in dorsal aspect for short distance at base of rostrum. Postorbital ridges weak, each with shallow, setiferous, dorsolateral groove, and terminating cephalically in corneous, acute, long spine. Suborbital angle obsolete. Branchiostegal spine moderately well developed and acute. Surface of carapace punctate dorsally and granulate laterally, three prominent cervical spines on left and two on right.

Abdomen longer than carapace (25.9 and 20.9 mm). Cephalic section of telson with single long spine in each caudolateral corner.

Epistome (fig. 6) broader than long, broadly rounded with very weak cephalomedian projection. Antennule of usual form with spine on ventral surface of basal segment distinctly distal to midlength. Antennae extending caudad beyond end of telson by distance almost equivalent to length of telson. Antennal scale (fig. 9) 2.6 times longer than broad with greatest width distal to midlength; lamellar area distinctly broader than thickened lateral portion, latter bearing long spine distally.

Right chela (fig. 12) elongate, subovate in cross section, and with palm slightly inflated; palm almost entirely tuberculate, tubercles along mesial and lateral surfaces elevated; remainder, except that on ventral surface just proximal to dactyl, mostly squamous; all with setae extending distally; tubercles forming two or three irregular rows along mesial surface of palm with 9 to 14 tubercles in each row. Opposable margin of immovable finger with row of eight small tubercles dorsally, extending from base to midlength of finger, single large tubercle ventrally near midlength, and longitudinal row of minute denticles (no more than three abreast) along almost entire length; dorsal and ventral surfaces of immovable finger with median longitudinal ridge, flanked, particularly dorsally, by setiferous punctations; lateral margin of finger tuberculate proximally and punctate distally. Opposable margin of dactyl with single large tubercle ventrally at base of distal three-fourths of finger and longitudinal row of minute denticles along almost entire length; dorsal and ventral surfaces as on immovable finger and mesial surface similar to lateral surface of immovable finger except basal tubercles slightly more conspicuous.

Carpus longer than broad (4.9 and 2.2 mm) with shallow oblique furrow on dorsal surface; dorsal surface mostly punctate; mesial surface with prominent acute tubercle distal to midlength and three or four smaller ones proximal or ventral to large one; ventral surface

with spine on mesiodistal margin and prominent tubercle lateral to it articulating with socket on ventral surface of propodus; lateral surface tuberculate.

Dorsal surface of merus with crowded small tubercles and single prominent spine near distal margin; lateral and mesial surfaces tuberculate dorsally and ventrally and punctate between; ventral surface tuberculate with lateral and mesial tubercles arranged in irregular rows of approximately 20 tubercles, distal tubercle of both rows very strong and sharp. Ischium with ventromesial margin irregular, bearing approximately 10 small tubercles, otherwise with setiferous punctations.

Hooks (figs. 8, 11) on ischia of third pereopods only; hooks simple and projecting proximally beyond distal margin of basis. Caudomesial surfaces of coxae of fourth pereopods (fig. 11) with very prominent tuberosities provided with long setae.

First pleopods (figs. 1, 5, 10, 11) symmetrical and extending cephalad to coxae of third pereopods when abdomen is flexed. See diagnosis for description.

ALLOTYPE FEMALE.—Excluding secondary sexual characters, differing from holotype in following respects: cephalic section of telson with two long spines in each caudolateral corner; opposable margins of fingers of chelae with single row of minute denticles, and opposable margin of dactyl with six small tubercles in proximal row instead of eight; tubercles on cheliped less well developed than in holotype.

Annulus ventralis (fig. 7) pigmented¹ (purplish tan), broader than long with slightly upturned (ventrally) lateral margins; broad shallow trough along median line with lateral areas very slightly inflated. Sinus semicircular and situated at extreme caudal portion of annulus, convexity of sinus extending cephalosinistrally. Sternal sclerite immediately caudal to annulus distinctly broader than long and without conspicuous ornamentation. Proannular plate absent. Sternal plate anterior to annulus unadorned but wings tipped with pigment similar to that coloring annulus. (See "Measurements").

MORPHOTYPIC MALE, FORM II.—Differs from holotype in following respects: spines and tubercles generally smaller, particularly more dorsal pair of cervical spines; cephalic section of telson with two spines in each caudolateral corner; opposable margin of immovable finger with upper row of tubercles reduced to two; upper opposable margin of dactyl with two tubercles between and at corresponding level of those on immovable finger; denticles on opposable margins of fingers more similar to those in allotype. Spines and tubercles elsewhere on cheliped reduced in size and numbers. Hooks on ischia of

¹ Probably a result of preservation; Mrs. Cooper has indicated she observed no pigment in any of the living individuals.

third pereopods well developed but not so long as in holotype; protuberances on coxae of fourth pereopods almost as well developed as in holotype.

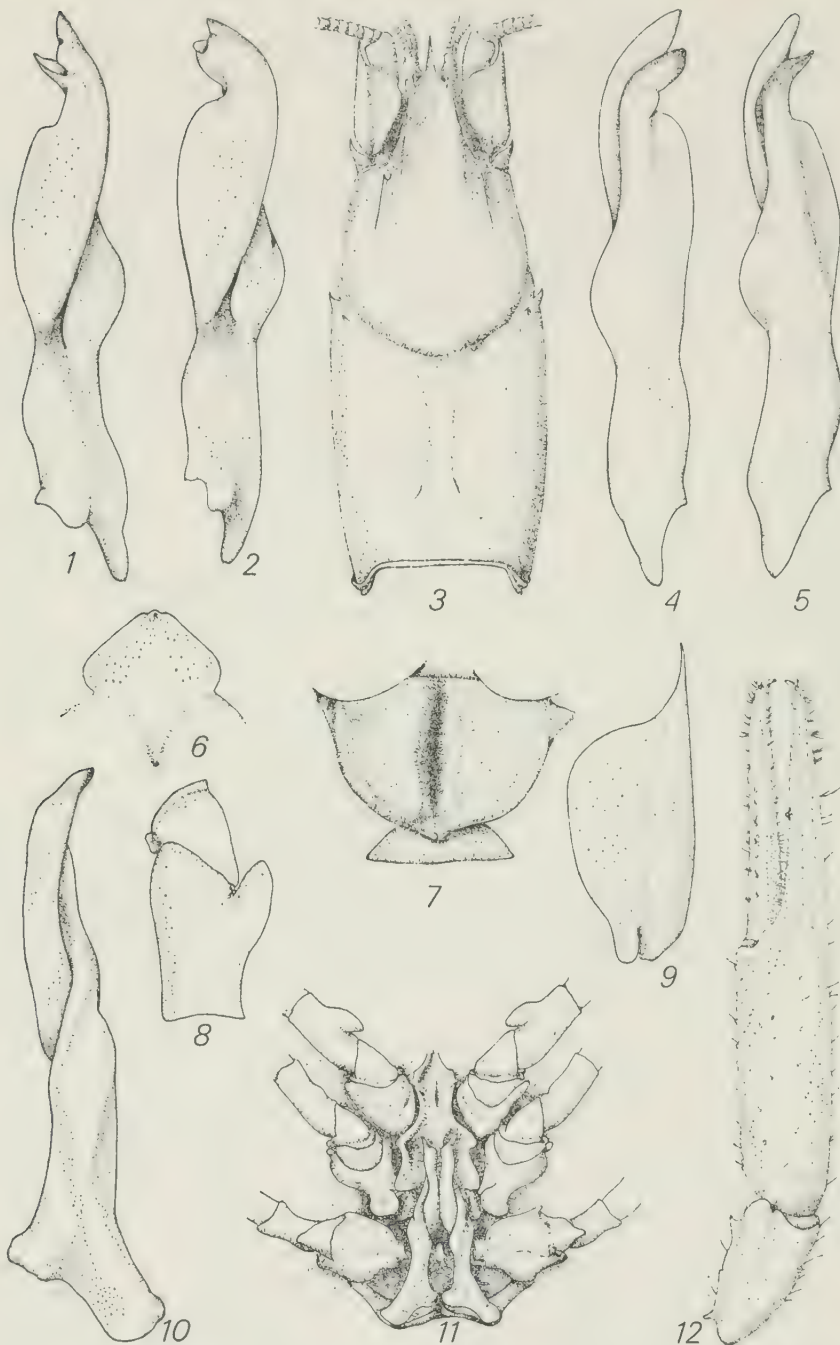
First pleopod (figs. 2 and 4) with both terminal elements, particularly central projection, heavier than in holotype; neither corneous, but both disposed as in holotype.

MEASUREMENTS (in millimeters).—

	holotype	allotype	morphotype
carapace			
height	7.3	6.1	6.3
width	8.8	7.7	8.0
length	21.6	18.9	18.8
rostrum			
width	2.6	2.5	2.4
length	6.2	5.5	5.0
areola			
width	1.4	1.4	1.4
length	9.0	7.6	7.4
chela			
length, inner margin of palm	6.5	5.5	5.0
width of palm	2.7	2.2	1.4
length, outer margin of hand	16.0	12.2	11.2
length of dactyl	8.5	6.6	5.3

SIZE.—The largest specimens available are two second form males from Key Cave, Lauderdale County, Ala., that have carapace lengths of 24.5 mm. The carapace of the smallest first form male, which is from the type-locality, is only 18.5 mm long. The largest female, also collected in the type-locality, has a carapace length of 20.9 mm.

TYPE-LOCALITY.—McKinney Pit Cave (Alabama Cave Survey, No. A-620, in files of ACS; see Tarkington et al., 1955), about 2.5 miles west of Tuscumbia, Colbert County, Ala. (Sec. 10, T 4S, R 12W). The entrance to the cave is a vertical sinkhole some 30 feet in depth, located at the foot of a ravine. After the initial drop, the level of the cave descends gradually to an irregular pool of standing water approximately 150 square feet in area and ranging in depth from one to four feet. The bottom is covered with a heavy layer of silt. The far end of this pool connects with extensive channels of deeper water. Following heavy rains, much debris from the surface apparently washes into the cave. In October 1966, following a drought, the pool originally visited had disappeared completely, and the water level in the cave had dropped at least four feet below that observed on two previous visits. (The foregoing is extracted from notes provided by Mr. and Mrs. Cooper; additional information concerning the cave and its fauna presently is being prepared for publication by them.)



FIGURES 1-12.—*Procambarus pecki*: 1, mesial view of first pleopod of first form male; 2, mesial view of first pleopod of second form male; 3, dorsal view of carapace of first form male; 4, lateral view of first pleopod of second form male; 5, lateral view of first pleopod of first form male; 6, epistome of first form male; 7, annulus ventralis of female; 8, basis and ischium of third pereopod of first form male; 9, antennal scale of first form male; 10, caudal view of first pleopod of first form male; 11, bases of third, fourth, and fifth pereopods and first pleopods of first form male; 12, distal podomeres of cheliped of first form male.

DISPOSITION OF TYPES.—The holotypic male, form I, the allotypic female, and the morphotypic male, form II, are deposited in the United States National Museum (nos. 117684, 117685, and 117686, respectively.) Of the paratypes, one male, form I, one male, form II, and a female are in the Museum of Comparative Zoology, a similar series in the Department of Zoology, Tulane University, and two males, form I, one male, form II, and six females are in the United States National Museum.

RANGE.—*Procambarus pecki* is known from two localities other than the type-locality. Four of the 18 specimens available were collected in Cave Spring Cave,² nine miles southeast of Decatur, Morgan County, Ala. (ACS No. 53) (Sec. 4, T 6S, R 3W), and two of them from Key Cave (ACS No. 99) just above the northern bank of the Tennessee River, about eight miles southwest of Florence, Lauderdale County, Ala. (Sec. 35, T 3S, R 12W). The type-locality and Cave Spring Cave are south of the Tennessee River whereas Key Cave lies on its north bank.

VARIATIONS.—In general, the specimens from Cave Spring Cave, Morgan County, have weaker spines than those from the type-locality, but for all other variations noted, specimens from one or the other locality exhibit the extreme ranges. The marginal rostral spines may reach the midlength of the ultimate podomere of the antennule; the cervical spines vary from one to three on each side, but in none of the specimens are there fewer than two on at least one side. The proximal section of the lateral ramus of the uropod bears from 7 to 13 spines along its distal margin. The chelipeds exhibit considerable variation in prominence and numbers of tubercles and spines. The annulus ventralis and the wings of the sternal plate immediately cephalic to it may or may not be pigmented.

LIFE HISTORY NOTES.—First form males were collected on Dec. 22, 1965, Apr. 16, 1966, and July 9, 1966. No ovigerous females, or females with young, or even young free in the water have been observed.

RELATIONSHIPS.—*Procambarus pecki* seems equally closely related to the troglobitic members of the genus *Oreconectes* and to the members of the Mexicanus Section of the genus *Procambarus*, and there are good reasons for assigning it to either of the two. Almost certainly it has had a common origin with both of the groups mentioned, and, while it resembles *O. p. pellucidus* (Tellkamp, 1844, p. 583) as strongly as it does any other species, at least some of the similarities almost certainly are due to convergence in response to a spelean environ-

² This is the type-locality of *Cambarus jonesi* Hobbs and Barr (1960, p. 19), listed by them as "12.1 miles northwest of Valhermosa." Mrs. Cooper has called my attention to the fact that we erred in quoting Dr. Jones' description of this cave, as his was that of another "Cave Spring Cave" in Madison County, Ala.

ment. The first pleopod of the male bears a close resemblance to *P. mexicanus* (Erichson, 1846, p. 99) and its allies, and, since the current definition of the genus *Procambarus* need not be modified to include this species, I am assigning it somewhat arbitrarily to *Procambarus*. In so doing, consideration has been given to this combination of morphological features in a crayfish situated in a geographic area that seems to be crucial from a phylogenetic standpoint (see below). Suffice it to say that, regardless of the genus to which it is assigned, the unique first pleopod of the male and annulus ventralis of the female will serve to distinguish it from any other described crayfish.

PHYLOGENETIC CONSIDERATIONS (figs. 13–21).—There is nothing extraordinary about certain species of closely related genera sharing characteristics of both genera; in fact, the existence of such species provides the best morphological evidence, in the absence of a fossil record, for conclusions that the genera share common ancestry. In the case of the crayfish genera *Orconectes* and *Procambarus*, several able students (Ortmann, 1905a; Rhoades, 1962; and Fitzpatrick, in press) have suggested that the former assemblage of species has had a common origin not too remote from *Procambarus*, and most, if not all, present workers would concede a derivation of *Orconectes* from some *Procambarus* stock. Largely on the presence of hooks on the ischia of the third and fourth pereopods, Faxon (1885, p. 18) referred *O. p. pellucidus* [= *Cambarus pellucidus*] to his Group I, which encompassed a large segment of the present genus *Procambarus*. Ortmann (1905a, p. 107) was aware of the *Procambarus*-like traits of *O. pellucidus* but argued that it should be included in the genus *Orconectes* [= his subgenus *Faxonius*].

Although no one has so stated, Hobbs (1942, p. 342) and Villalobos (1955, p. 46) realized the difficulty of defining the genus *Procambarus* in such a way as to include *P. mexicanus* and most of its close relatives. Without the statements “if pleopods terminate in two parts, shoulder always present” in the diagnosis of *Procambarus* and “Never is a strongly developed shoulder present on the cephalic margin near the tip of the appendage” in the diagnosis of *Orconectes*, all but one member of the Mexicanus Group would have to be included in the genus *Orconectes*. As is implied, the key generic differences between members of the two genera exist in the first pleopod of the male. All but one member of the genus *Orconectes*, *O. p. australis* (Rhoades, 1941, p. 142), possess a first pleopod ending in two parts, whereas few species of *Procambarus* have such a pleopod. Most members of the latter have at least three terminal elements on their first pleopod, and the majority, four or five. For this and other reasons, Hobbs (1962, p. 278) postulated that the pleopod of the ancestral form of the genus *Procambarus* terminated in four distinct parts.

None of the students of crayfishes, to my knowledge, have questioned the primitiveness of the Limosus Section of the genus *Orconectes*, as originally pointed out by Ortmann (1905a, p. 108), and none since have denied that that assemblage embraces or has close affinities with the troglobitic species ranging from Indiana to Alabama. (There is disagreement concerning the taxonomic treatment of the epigeal and spelean members of the section (Rhoades, 1944; Hobbs, 1948; Creaser, 1962), and Creaser has taken issue with the generic nomenclature that was proposed by Hobbs (1942), but this is of little consequence in the context of the present discussion.)

A comparison of the troglobitic members of the genus *Orconectes* with members of the genus *Procambarus* demonstrates that these troglobites possess a distinctly advanced first pleopod of the male that is approached most closely in the genus *Procambarus* by the species of the Mexicanus Group. Only one species of this group, *P. acanthophorus* Villalobos (1948, p. 175), can be claimed on the basis of the pleopod to be more generalized, for it is the only member of the group in which the first pleopod terminates in three rather than two parts (a small cephalic process is present.)

Were the first pleopods considered alone in assessing the primitiveness of the Mexicanus Group among its relatives in the genus *Procambarus*, one would be almost forced to conclude that the group is an advanced one within the genus (see Hobbs, 1962, p. 276). There is, however, additional evidence that the group is indeed an advanced segment of it: (1) the males are provided with ischiopodal hooks only on the third pereopods; (2) the majority of the species have comparatively long narrow areolae, usually denoting a broad ecological tolerance; (3) most members have few spines, often associated with a secondary burrowing (advanced) habit; (4) there is a unique sternal modification (here designated the proannular plate) immediately anterior to the annulus ventralis of the females that is encountered elsewhere in the family only in the members of the Cubensis Group; and (5) the comparatively long, slender chelipeds of the males most definitely are not of a primitive type. If the members of the Mexicanus Group thus are to be considered as close relatives of the primitive *Orconectes*, one might well conclude that *Orconectes* has been derived not from the more primitive but from an advanced segment of the genus *Procambarus*. One must not conclude, however, that it was from the Mexicanus Section of the genus that the primitive *Orconectes* was derived, for a few primitive characteristics are retained in the troglobitic *Orconectes*, some that do not exist in the Mexicanus stock: (1) multiple cervical spines in most of them; (2) a rudimentary caudal process on the first pleopod of the male in *O. pallucidus australis*; (3) hooks on the ischia of the third and fourth pereopods; and (4)

the absence of a proannular plate in the females. It does seem probable, nevertheless, that the primitive *Orconectes* did have a more recent common ancestry with the members of the Mexicanus Section than with other segments of the genus *Procambarus* and that *Procambarus pecki* also shares in this ancestry.

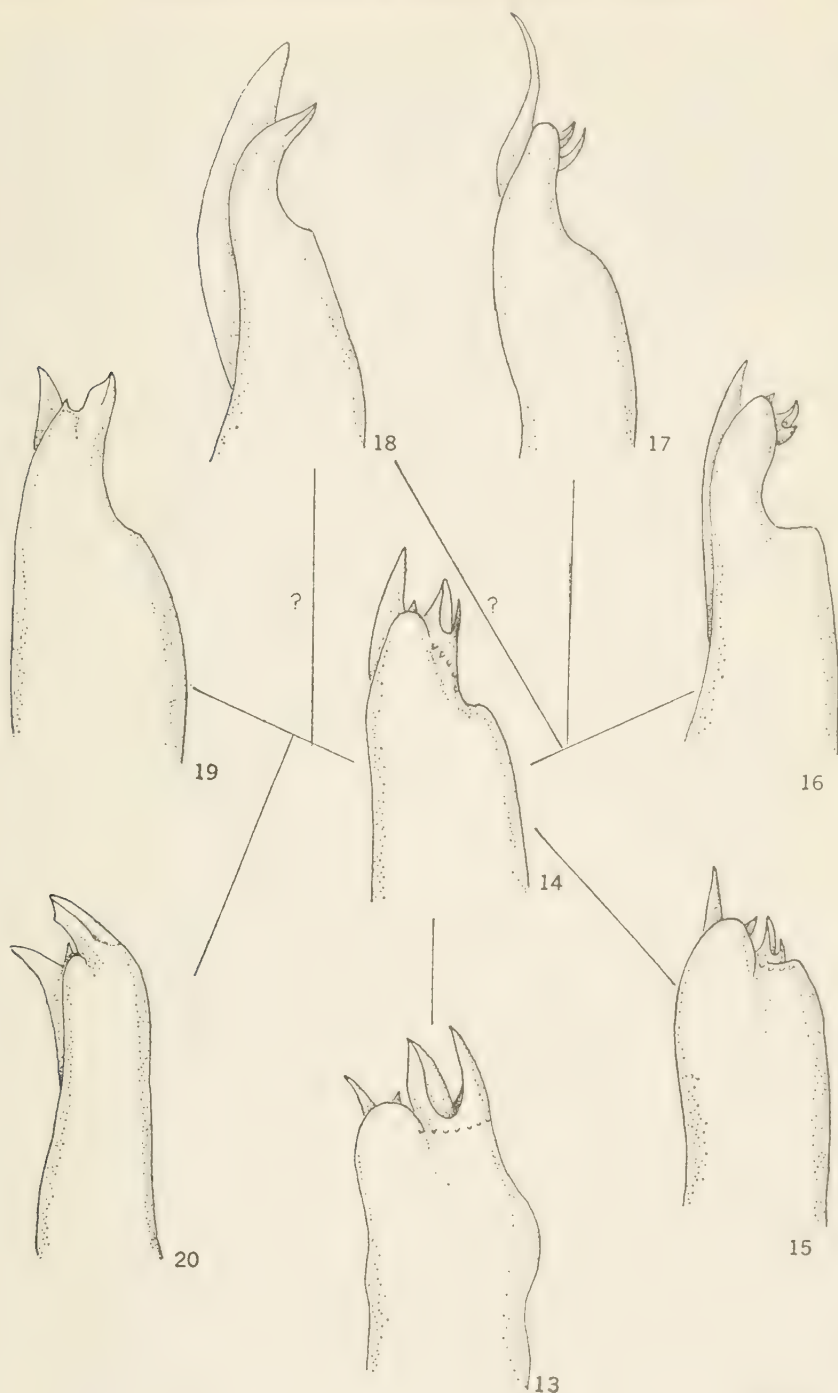
It is postulated here that the ancestral stock from which originated *P. pecki*, the Mexicanus and Cubensis Groups of the genus *Procambarus*, and the genus *Orconectes* possessed, among others, the following characteristics: (1) a long rostrum with prominent marginal spines and acumen; (2) a broad and short areola; (3) multiple (more than one) cervical spines on each side; (4) subcylindrical to subovate chelae with elongate and entirely tuberculate palms; (5) symmetrical first pleopods in the first form male with four short terminal elements, the cephalic process reduced, and with a shoulder distinctly proximally removed from the base of the central projection on the cephalic surfaces of the appendages (fig. 14); (6) hooks on the ischia of the third and fourth pereopods in the male; and (7) an inflated, oval annulus ventralis without a median depression, and with a short arclike sinus on the caudal declivity.

In *Procambarus pecki*, the primitive characteristics of the stock are maintained in the rostrum, cervical spines, and chelae. The areola has become elongated; the first pleopod has lost both the cephalic and caudal processes; hooks are present on the ischia of only the third pereopods; and the annulus ventralis has developed a prominent median longitudinal depression.

Utilizing a combination of the most primitive characters represented in the members of the Mexicanus Section, it is postulated that the stock moving into Mexico, and subsequently into Cuba, retained the primitive condition of the rostrum, areola, cervical spines, and chelae, and modified the first pleopods as depicted in figure 14. It lost, however, hooks on the ischia of the fourth pereopods, and the females developed a prominent sternal plate, a proannular plate, immediately cephalic to the annulus ventralis.

Again, combining the most primitive characteristics represented in the Limosus Section of the genus *Orconectes*, their ancestors retained the primitive rostrum, areola, cervical spines, hooks on the ischia of the pereopods, and annulus ventralis. The major alterations were in the chelae, in which the uniform tuberculate condition was reduced largely to two rows along the upper inner margin of the palm, and in the first pleopod, in which the cephalic process was lost completely and the caudal process reduced to a rudimentary spine (fig. 19).

To a considerable degree, along with divergence, parallel evolution has progressed in the evolution of *P. pecki*, the primitive *Orconectes*, and the Mexicanus stocks. In general, in all three the areola has under-



FIGURES 13-20.—First pleopods of first form males: 13, generalized *Procambarus* (see Hobbs, 1962, p. 275); 14, hypothetical ancestor of stocks and species indicated; 15, hypothetical ancestor of the barbatus and gracilis sections of *Procambarus*; 16, hypothetical ancestor of the Mexicanus Section of *Procambarus*; 17, *Procambarus alleni* (Faxon); 18, *Procambarus pecki*; 19, hypothetical ancestor of *Orconectes* and *Faxonella*; 20, hypothetical ancestor of *Cambarus*.

gone a lengthening and narrowing; only in *P. atkinsoni* (Ortmann, 1913, p. 414) (Isle of Pines) is the primitive condition retained. There has been a tendency to reduce the number of cervical spines to a single one so that the multiple condition persists only in *P. pecki*, *O. pellucidus* (Kentucky to Alabama), *O. limosus* (Rafinesque, 1817, p. 42) (eastern United States), *P. acanthophorus*, *P. llamas* Villalobos (1954, p. 364), *P. pilosimanus* (Ortmann, 1906, p. 6) (Guatemala to southern Mexico), and *P. williamsoni* (Ortmann, 1905b, p. 439) (Guatemala), and it has been reduced to a small tubercle or completely obliterated in *O. pellucidus testii* (Hay, 1891, p. 148) (Indiana) and in several of the Mexican species. A reduction in the number of terminal elements of the pleopod is a characteristic of the three; among the species of the genus *Orconectes*, all have only the mesial process and central projection except *O. pellucidus australis* (Alabama and Tennessee), which has in addition a minute caudal process; in *P. pecki* no traces of the cephalic and caudal processes are present; in the members of the Mexicanus Section, the cephalic process is retained only in *P. acanthophorus*, and the caudal process proper only in the Cuban forms. Hooks on the ischia of the pereopods have been reduced to those on the third in all except *O. pellucidus* and *O. quadruncus* (Creaser, 1933, p. 10) (Missouri). The primitive, ovate, swollen annulus ventralis has developed a groove similar to that in *P. pecki*, both in most of the Mexican representatives of the Mexicanus Section and in the genus *Orconectes*.

To a lesser degree, evolution in the genus *Cambarus* has paralleled that of the three mentioned above. While some of the more primitive species have retained the broad, short areola, in most it has been narrowed and lengthened. The multiple cervical spines are retained only in the troglobitic *C. hamulatus* (Cope and Packard, 1881, p. 881) (Tennessee) and *C. setosus* (Faxon, 1889, p. 237) (Missouri); even in some specimens of these species the number has been reduced to one, and the one sometimes represented by a tubercle. The primitive pleopod of *Cambarus* (fig. 20), like that of the primitive *Procambarus*, possessed four terminal elements, but the cephalic process had shifted to a position mesial to the shaft and is known to exist in only two extant species, *C. strawni* Reimer (1966, p. 11) (Arkansas) and in a species from Louisiana, the description of which by Black is in press. The caudal element is reduced to a small caudal knob that is best developed in *C. pristinus* Hobbs (1965, p. 268) (Tennessee), but vestiges of it occur in several other species of the genus; in most, however, it is absent. Most species of the genus may be characterized by possessing a first pleopod with only two terminal elements (mesial process and central projection) that are directed approximately at a right angle to the shaft of the appendage. The primitive condition

of the hooks on the ischia of the third and fourth pereopods is maintained only in *C. dissitus* Penn (1955, p. 73) (Louisiana) and the undescribed species mentioned above; all others have them only on the third pereopods. The annulus ventralis in all species has elements of the median longitudinal trough; thus, the same trends that were pointed out for *Orconectes* and the Mexicanus Section of *Procambarus* and that were attained in *P. pecki* are apparent in the evolution of the genus *Cambarus*.

Figures 13 through 20 depict a hypothesis relating the ancestry of the genera *Orconectes*, *Faxonella*, and *Cambarus*, the Mexicanus, Barbatus, and Gracilis Sections of the genus *Procambarus*, and the disjunct *P. pecki* and *P. alleni* (Faxon, 1884, p. 110). Figure 13, representing the generalized first pleopod of *Procambarus* is redrawn from Hobbs (1962, p. 275); references to the original figure will enable the reader to associate the species groups discussed here with other segments of the genus *Procambarus*.

The chief pre- or early-Miocene changes postulated in the evolution of the first pleopod of the males of this stock (fig. 14) are (1) the accentuation of the shoulder on the cephalic surface, (2) a narrowing of the cephalic-caudal plane in the distal portion of the appendage, (3) the beginning of an elongation of the caudal knob, and (4) a reduction in the size of the cephalic process and its becoming more intimately associated with the central projection.

In the Mexicanus-Cubensis stock (fig. 16), the distal portion of the appendage became elongate and slenderer, thus accentuating the shoulder; the cephalic process and central projection were reduced in size, and the subapical setae lost.

In *P. alleni* (fig. 17), the distal portion of the appendage became even more attenuate than in the Mexicanus-Cubensis stock, and the central projection disproportionately smaller than the cephalic process. The subapical setae were retained and extend along the margin of the rounded shoulder.

In the Barbatus-Gracilis stock (fig. 15), the distal portion of the appendage was shortened, bringing the terminal elements and the subapical setae to the level of the cephalic shoulder. The subterminal setae were subsequently lost in the members of the Gracilis Section.

In the *Orconectes-Faxonella* stock (fig. 19), the cephalic process and subterminal setae were lost, the caudal element reduced to a vestige, the mesial process shortened to project little farther than the central projection, and the latter somewhat broadened in the cephalic-caudal plane.

The *Cambarus* stock (fig. 20) lost the cephalic shoulder and subapical setae, markedly reduced the caudal element to a small knob, shifted the cephalic process to a mesial position at the morpholog-

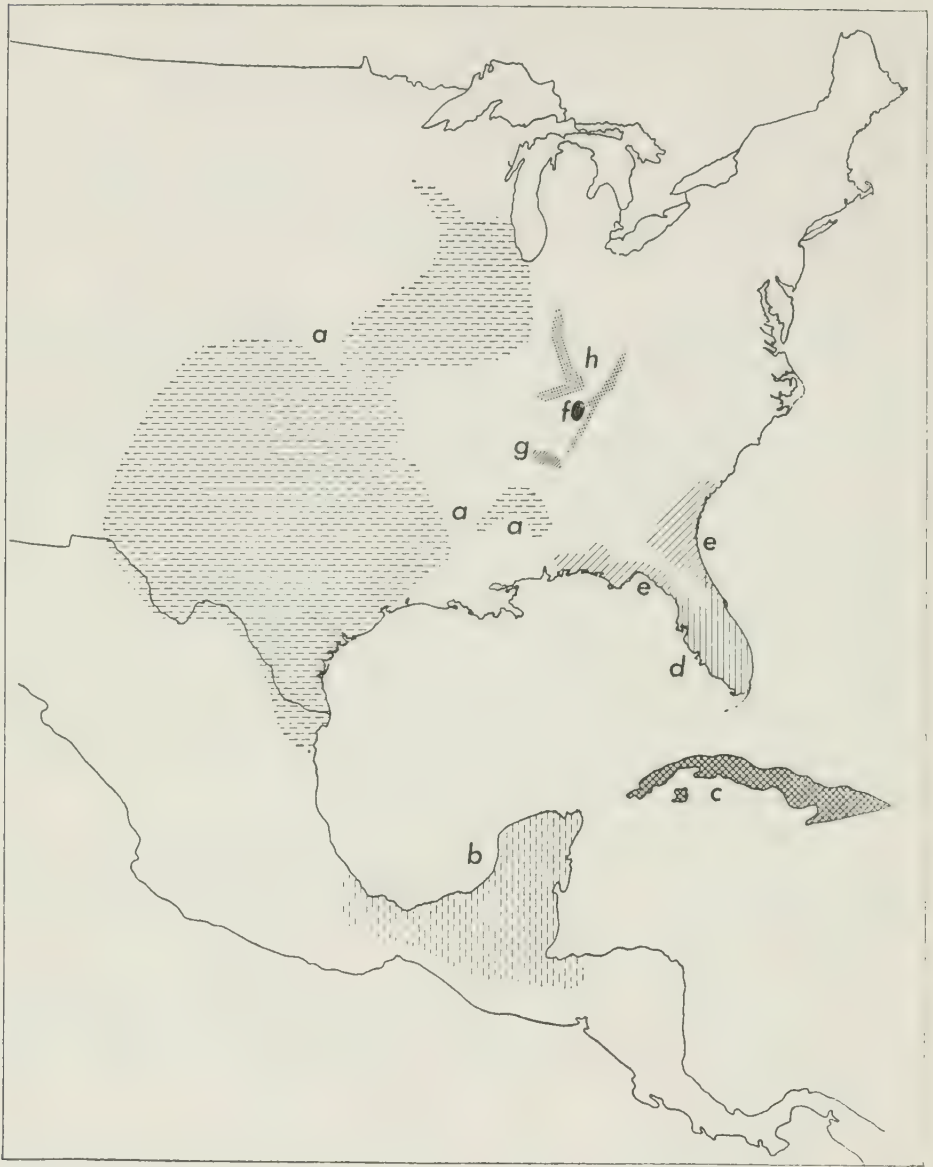


FIGURE 21.—Ranges of *Procamburus pecki* and its allies: *a*, Gracilis Section; *b* and *c*, Mexicanus Section (*b*, Mexicanus Group; *c*, Cubensis Group); *d*, *Procamburus alleni*; *e*, Barbatulus Section; *f*, primitive *Cambarus* (*C. pristinus* and *C. obeyensis*); *g*, *Procamburus pecki*; *h*, troglobitic *Orconectes*.

ical cephalic base of the mesial process, and initiated a subparallel recurving of the latter and central projection.

In the evolution of *P. pecki* (fig. 18), the shoulder was retained, and the distal portion of the appendage became very slender; the subapical setae, the cephalic process, and caudal elements were lost, and the two remaining apical processes assumed positions similar to those in *P. alleni* and the Mexicanus-Cubensis stock.

A consideration as to the range and time of the existence of the ancestral stock from which these crayfishes have been derived has resulted in the hypothesis that the ancestral precursors occupied an area of the southeastern United States that extended northward from Alabama and encompassed the Cumberland Plateau. Because of the presence of *O. pellucidus australis* in the subterranean refugia of the Cumberland Plateau and the contiguous limestone areas south to Alabama, of the primitive *Cambarus pristinus* and *C. obcyensis* Hobbs and Shoup (1947, p. 138), both occupying limited ranges on the Plateau, and of *P. pecki* in northern Alabama, it seems probable that the centers of origin for *Orconectes*, *Cambarus*, and the Mexicanus Section of the genus *Procambarus* existed in the area of northern Alabama northward through the limestone belt of Tennessee onto the Cumberland Plateau.

This differs slightly from the postulate proposed by Ortmann (1905a, plate 3) that the center of origin for the genus *Orconectes* (=his subgenus *Faxonius*) was situated somewhat more to the west and did not embrace the Cumberland Plateau.

In the area of the Cumberland Plateau, much of the primary divergence in the genera *Orconectes* and *Cambarus* occurred with stocks radiating from this center: in *Orconectes* principally to the north and west, and in *Cambarus*, for the most part, to the east and south, although two or three stocks of the latter moved westward and reached the Ozark-Ouichita region relatively early. *Procambarus pecki* probably remains in the area of its ancestral home but its closest relatives moved southwestward into Mexico and to Cuba.

Villalobos (1955) has discussed the origin of the Mexicanus Group, and Hobbs and Villalobos (1964) have considered the origin of the Cubensis Group. Their conclusions are that, inasmuch as the Mexicanus Group occupies an area south of the Cordillera Volcánica Transversal, which arose no later than the late Tertiary and probably during the upper Miocene, the arrival of the ancestral stock of this group in the area to the south of these mountains must have occurred sometime prior to the end of that era. They also joined other earlier students of Antillean zoogeography in postulating a tertiary land bridge between Cuba and the Central American-Mexican region across which members of this stock reached Cuba. In light of recent studies (including Kendall and Schwartz (1964) on the ability of cambarine crayfishes to tolerate higher salinities than has been supposed, a land bridge seems less a necessity than before. Regardless, however, of the means by which the crayfishes reached Cuba, the time of their arrival on the island must have been prior to the Pleistocene and probably as early as the Miocene.

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Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3622

BREDIN-ARCHBOLD-SMITHSONIAN BIOLOGICAL SURVEY OF DOMINICA

5. Family STRATIOMYIDAE (Diptera)¹

By MAURICE T. JAMES²

Fourteen species of Stratiomyidae are represented in the collections, 9 or probably 10 of which apparently are new to science. Three of the previously known species, *Hermetia illucens* (Linnaeus), *Microchrysa bicolor* (Fabricius), and *Sargus notatus* Wiedemann, are widespread throughout the Neotropical Region, although the last of these is represented, as noted below, by an Antillean form that differs in appearance from most mainland material. The interesting distribution of *Artemita inornata* (Williston) is discussed under the heading of that species. The remaining species, except the unnamed *Nemotelus* and the new *Pachygaster*, show distinct Neotropical affinities. *Cyphomyia dominicana* is a member of an Antillean complex, with a closely

¹ Other faunal studies in this series are: 1, Kier, Proc. U.S. Nat. Mus., 1966, vol. 121, no. 3577, pp. 1-9; 2, Stone, *ibid.*, 1966, vol. 121, no. 3578, pp. 1-6; 3, Kirsteuer, *ibid.*, 1967, vol. 123, no. 3610, pp. 1-6; 4, Allen, *ibid.*, 1967, vol. 123, no. 3617, pp. 1-4. A companion series on the flora appears in the "Contributions of the United States National Herbarium." The present paper also is Scientific Paper 2930, College of Agriculture, Washington State University; the work was conducted under Project 9043.

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related species in St. Vincent and another to the north of Dominica; *Pelagomyia illucens* has a close relative in St. Vincent; and the remaining species have closest relationships with mainland South and Middle American forms.

Notes on color and pattern of eyes of several species, made on live and recently killed specimens, have been furnished by George C. Steyskal (see also figs. 8-13).

Cyphomyia dominicana, new species

FIGURES 1, 7, 8

MALE.—Head mainly black; frontal triangle a sordid yellowish brown, this color extending very slightly below bases of antennae laterally; face mostly with a dark blue, metallic sheen. Frontal triangle with long black pile; face with dense pale yellow tomentum, thickest laterally but, when viewed dorsally, obscuring most of the face; some longer semi-erect yellow pile below and some scattered, mostly black, long, erect hairs in the middle of the face; narrow occipital orbits yellowish tomentose except on dorsal third, where the orbits vanish; genae and lower occiput with erect whitish to pale yellow hairs. Eyes uniformly but not thickly covered with long pile, almost as long as first antennal segment, mostly black but some whitish below. Proboscis yellowish brown, with pale hairs. Antennae black, flagellum reddish brown toward base on inner surface, elongated, tapering to terminal segment, which is in the form of a greatly attenuated cone, almost tubular, and ending in a small hair; flagellum 0.54 to 0.60 head width.

Thorax mostly black, some brownish areas on pleura, especially below wing base; mostly with dark bluish reflections; mesonotum with appressed black and pale yellow, dense tomentum and fairly abundant erect, long, mostly blackish pile; the black tomentose coverings in the form of two broad median vittae that appear confluent before the suture in most lights and two broad lateral post-sutural vittae; scutellum with pale yellow tomentum and semi-erect pile and with considerable long, erect pile as on mesonotum; pleural pile and tomentum more whitish; a glossy band from front coxa to notopleural suture. Scutellar spines on a level with scutellum, somewhat divergent, as long as scutellum, tending to become brownish beyond base; hairs of spines long, mostly black dorsally and yellow ventrally. Legs mostly black with some bluish reflections; knees yellow; front and middle basitarsi yellow, becoming blackish apically; second tarsomere of fore- and middle tarsi and hind basitarsus more or less yellowish below and at base. Wings hyaline; veins brown; stigma pale yellowish brown; second basal and anal cell each with

only a small patch of microtrichia at apex; alula devoid of microtrichia except anteriorly.

Abdomen black with dark blue-green reflections over most of its surface; dorsally with long, erect black hairs and short semi-erect black pile; some pile on posterior angles of first tergum whitish; a silvery tomentose spot on each anterior angle of fourth and fifth tergum; venter with abundant short, semi-erect whitish pile. Genitalia as in figure 1; dististyli conically tapering; guards of aedeagus extending well beyond intromittent organ, which is blunt apically. Length 8.5–9.0 mm.

FEMALE.—Frons narrow, at narrowest 0.11 to 0.12 head width, almost parallel sided but widening toward antennal bases; lower part of frons, including callus and area below reaching ventrad just below antennal bases, brownish yellow. No black pile on head; frons and vertex, including ocellar triangle and area between it and each eye, with dense pale yellow tomentum. An extremely narrow, low carina extending along midfrontal line about half way or more to callus; lower frons depressed medially below callus. Occipital orbits narrowly but uniformly developed, about one-half width of frons, and wholly pale yellow tomentose. Pile of eyes very short. Thorax as in male but without erect black hairs and without the black-tomentose median vitta discretely separated. Scutellar spines more robust, 0.65 to 0.75 length of scutellum, usually wholly black or bluish black, sometimes becoming brownish yellow apically. Stigma somewhat more brownish than in the male, but still pale; membrane with a slight tendency toward browning. Abdomen more bluish than in male, with lateral silvery-tomentose area on third as well as fourth and fifth terga, these patches slightly more conspicuous than in male. Ovipositor brown, dull, with very short stiff black hairs; cerci yellow. Length 5.0–9.0 mm.

COLOR OF EYE IN LIFE.—Male: Scarlet in ground color with distinct narrow median wedge of brassy green; also one or two faint brassy green wedge-shaped marks in lower half and sometimes a faint anterior area of brassy green in upper half (fig. 8).

PUPARIUM.—A dorsal view of the head and prothorax is shown in figure 7.

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE.—♂ with puparium, Clarke Hall, Nov. 12–17, 1964, P. J. Spangler type no. 69516, USNM.

ALLOTYPE.—♀, Clarke Hall, Mar. 21–31, 1965, malaise trap, W. W. Wirth.

PARATYPES.—2 ♂♂, 1 ♀, all with puparia, same as holotype; 11 ♀♀, same as allotype but Jan. 8 to Feb. 20; 5 ♀♀, Clarke Hall, May 21 to June 2, 1966, G. Steyskal; 1 ♀, South Chiltern, Dec. 8–10,

1964, Spangler; 1 ♀, same, Mar. 25, 1964, H. Robinson; 1 ♀, no locality, July 1964, F. D. Bennett.

REMARKS.—A group of five known species, all from Florida and the Caribbean area, show close relationships to one another. These are *Cyphomyia chalybea* (Wiedemann), the type of Osten Sacken's nominal genus *Neorondania* (= *Rondania* Jaennicke, 1867, preoccupied by *Rondania* Bigot 1854), *C. marginata* Loew, *C. lasiophthalma* Williston 1896 (not Williston 1900), *C. brevis* James, and the present species. *Cyphomyia anchialus* Walker is probably, as Kertész considered it, a synonym of *C. chalybea*. All species are relatively short and stocky for the genus, with hairy eyes and an antennal flagellum that tapers to an acute style. There are only minor differences, possibly not constant, in the structure of the male genitalia. *Cyphomyia brevis* has very short eye pile in both sexes and the femora are reddish yellow, contrasting with the darker, brownish tibiae; *C. marginata* is easily separable by its reddish-brown scutellum.

The remaining three species are more difficult to separate. *Cyphomyia chalybea* differs from *C. dominicana* in its shorter antennal flagellum (less than half the head width); the flagellum is broadly reddish yellow on its basal four or more segments, and the silvery tomentose spots on the abdomen are much more conspicuous than in *C. dominicana*. The description of *C. lasiophthalma* from St. Vincent agrees with *C. dominicana* in most respects except for the metallic blue color of the frontal triangle in the male and the assumption one must draw from the description that the eyes of the female, like those of the male, have long pile. Two males from Grenada (Botanical Gardens, Nov. 12, 1918, Harold Morrison) agree with Williston's description and seem to be his species; as in *C. chalybea*, the base of the flagellum (three segments) is distinctly reddish yellow and the silvery abdominal spots are relatively conspicuous; the antennal flagellum is 0.50 the head width.

Pelagomyia illucens, new species

FIGURE 2

Close to the type-species of the genus, *P. albitalus* Williston from St. Vincent; that species is described as having the face, frons, and thorax shining deep green and the thorax with erect black pile, a characterization that does not apply to the Dominican species. *Pelagomyia fasciata* (Thomson) (= *P. dubia* Curran), from the Galápagos Islands, is a nonmetallic species with very short pile on the eyes.

MALE.—Head mainly shining black, in certain lights with dull green reflections; a narrow transverse yellow band on upper part of

frontal callus continued ventrad in the middle across the antennal bases and expanding onto an indefinitely outlined facial area that may, in turn, expand into a transverse band across the middle of the face. Some yellow pile at lower posterior angle of eye, head otherwise with rather dense, erect black pile. Vertex in holotype 0.27 head width, widening to 0.36 head width at callus, then narrowing to 0.30 head width across oral margin. Eyes with dense black pile that is somewhat longer than second antennal segment. Antenna as in *P. albitalus* (cf. Williston's figure reproduced in Curran, 1934, p. 136), black haired. Proboscis pale yellow with some black but mostly with concolorous hairs.

Thorax black, with blue-green reflections, particularly under certain lights, these reflections more obvious than on the head. Thoracic pile chiefly golden, that of mesonotum mostly tomentum-like but semi-erect to erect laterally, that of pleura mostly semi-erect; some erect black mesonotal pile but, except when viewed posteriorly, this is much less conspicuous than the golden pile; pleura also with patches of short, erect black pile or with black hairs intermixed with the golden, but this again less conspicuous than the golden pile. Squamae mostly brown, their fringes coppery. Halteres greenish yellow. Coxae, trochanters and femora except apices black; front and middle tibiae more or less brownish on median half, hind tibia blackish on apical half; last tarsomere of front and middle tarsi yellowish brown; hind tarsus from apical part of basitarsus blackish; tibiae and tarsi otherwise whitish. Wing distinctly infumated beyond base of discal cell, subhyaline at base; extreme wing base and second basal and anal cells except extreme apex devoid of microtrichia; vein r-m strongly arcuate; R_{2+3} arising beyond r-m by more than length of r-m.

Abdomen black; a large translucent area usually taking up most of the first segment and a part, sometimes most, of the second, resulting from a pale, translucent integument both dorsally and ventrally; sometimes, but not usually, the suggestion of a division of this area along a median line. Second to fourth abdominal segments almost parallel sided. Abdomen with appressed black pile over most of the dorsum and on venter except for first sternum, where the appressed hairs are yellow. Second to fourth terga each with an apical narrowly interrupted golden tomentose band; first three terga with golden erect to semi-erect lateral pile. Genitalia black; ninth sternum prolonged laterally on each side into processes that curve medially, the dististyli arising inconspicuously medially of these processes and ending before their apices (fig. 2); aedeagus trifid, the guards cylindrical and bowed gently outward at apex, the intro-mittent organ also cylindrical. Apicoventral part of ninth sternum

bridgelike, the part basad of it receding and convex, polished. Length 8–11 mm.

FEMALE.—Very similar to the male; metallic reflections of head and mesonotum more bluish; thoracic and abdominal tomentum and pale pile yellowish rather than golden; abdominal ground color entirely black or almost so.

COLOR OF EYE IN LIFE.—Plain dark olive green.

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE AND ALLOTYPE.—♂ and ♀, respectively, in copula, Clarke Hall, June 12, 1966, G. Steyskal, type no. 69517, USNM.

PARATYPES.—8 ♂♂, same but May 19 to June 2; 3 ♂♂, same but Mar. 12 and Apr. 11, 1964, H. Robinson; 1 ♀, same but Mar. 21–31, 1965, light trap, W. W. Wirth; 3 ♂♂, same but Apr. 5 and 12, 1964, O. S. Flint, Jr.; 1 ♂, same but Mar. 3–13, 1965, H. E. Evans; 1 ♂, near Clarke Hall, Mannett Gutter, May 1, 1964, Flint.

REMARKS.—The name “*illucens*” is doubly appropriate in describing the translucent abdominal area and in indicating the superficial resemblance to a small specimen of *Hermetia illucens* (Linnaeus).

A comparison of the structure of the genitalia with that of *Chrysochlorina* (cf. Iide, 1966), particularly in respect to the interesting development of the ninth sternum, leads to further confirmation of the concept of the relationship of the two genera. Williston (1896) states that he at first considered *P. albitalus* to belong to the genus *Chromatopoda*; this genus likewise has a similar type of genitalia and clearly is a chrysochlorine in this and other respects.

Hermetia illucens (Linnaeus)

DISTRIBUTION.—Widespread, Old and New World tropics, subtropics, and warmer temperate regions.

I have the following records from Dominica: 9 ♀♀, 2 ♂♂, Clarke Hall, Dec. 1–6, 1964, P. J. Spangler, Jan. 18 to Mar. 11, 1965, J. F. G. and Thelma Clarke, Feb. 10–17, 1965, H. E. Evans, Jan. 11–31, 1965, malaise trap, W. W. Wirth, and June 1–2, 1966, G. Steyskal; 1 ♀, South Chiltern, Dec. 8–10, 1964, Spangler; 2 ♂♂, 1 ♀, Soufriere, June 4, 1966, Steyskal.

Brachycara slossonae (Johnson)

Although there is no material of this species in the collection from Dominica, there are 4 ♂♂ (St. Johns, Antigua, Feb. 2 to Mar. 14, 1965, H. E. Evans) taken on the Bredin-Archbold-Smithsonian Expedition. This species was described from Florida and occurs in the West Indies, as far south as Tobago.

Nemotelus (Camptopelta) species

One male (Clarke Hall, Jan. 21–31, 1965, malaise trap, W. W. Wirth) apparently represents a new species, but it is unwise to describe it on the basis of a single specimen. In Hanson's (1963) revised key, it traces to *N. glaber* Loew; it is smaller and more shiny than the mainland material of *N. glaber* that I have seen.

Sargus notatus Wiedemann

This widespread Neotropical species is represented in Dominica by a form that might be recognized at least as a distinct subspecies were it not for the following facts: (1) a disturbing variant occurs, along with the better represented form, in this very restricted geographical area; (2) other faunas, including those of very restricted areas, show too much intergradation occurring in the sampled series.

Most of the series recorded here from Dominica show the following combination of characters in the females:

Frons narrow, at narrowest 0.13–0.14 head width; sides of upper frons and vertex glabrous, this area narrow and parallel sided, no wider than transverse diameter of adjacent posterior ocellus; sides of frons anterior to ocellar triangle strongly punctured and rugulose anteriorly; a glabrous stripe, about one-third width of frons, extending anteriorly from anterior ocellus but merging into the punctured areas well before the callus; upper margin of callus convex. Pile of frons and vertex black, that of occiput yellowish. Abdomen blue with purplish reflections; apex of first tergum and anterior margin of second more or less yellowish; a small triangle at each posterior angle of second to fourth terga yellow, with whitish pile. Hind femur at base, hind tibia except basal third to half, apical third of hind basitarsus and subsequent tarsomeres, all black, legs otherwise yellow. Color of eye in life dark green with bronzy sheen.

Females that I have seen from the American mainland have the second tergum yellow except for a spot on each side; on the other hand, females from Grenada, Jamaica, and Puerto Rico have the second tergum as in the Dominican form. This would seem to indicate at least an Antillean subspecies except that the other characters indicated for the Dominican form are all variable; also, two of the Dominican females show some intermediacy in the coloration of the second tergum in that there are suggestions of a pale area comparable to that of the continental form; moreover, some specimens in a series from Barro Colorado Island, Canal Zone, are identical with the Dominican form except for the pale second tergum.

Males seem to be alike in the island and the continental forms; I can see no differences in the genitalia as well as in other characters.

The black coloration on the hind legs is less intense and, particularly on the femur, less extensive, but usually developed only subbasally. Two females have this coloration as in the males; two males have the hind femur and tibia almost wholly yellow.

The continental form has the frons of the female wider, usually 0.17–0.18 the head width, less densely punctured, and with the glabrous stripe adjacent to the eye on the upper frons and vertex wider, usually widest opposite the posterior ocellus and distinctly wider than the transverse diameter of the ocellus; the median glabrous area anterior to the anterior ocellus is more than one-third the width of the frons; the pile of the ocellar triangle and vertex and sometimes entire frons is yellow, and the yellow area on the second tergum is conspicuous. As indicated above, however, all of these characters except the last are variable in both the continental and island forms, though constant for the Dominican series except as indicated above.

The North American and Cuban *Sargus lucens* Loew (= *S. clavis* Williston, = *S. tricolor* Loew) fits also into this same complex. We may be dealing here with a single polytypic species.

DISTRIBUTION.—Throughout the Lesser and Greater Antilles, and most of the tropical American mainland.

I have the following records from Dominica: 14 ♀♀, 8 ♂♂, Clarke Hall, Jan. 24 to Feb. 28, 1964, H. Robinson; Nov. 19–30, 1964, P. J. Spangler; Sept. 1, 1965, J. F. G. Clarke; Jan. 21 to Mar. 10, 1965, light trap, W. W. Wirth; Feb. 20–28, 1965, H. E. Evans; June 6–11, 1966, G. Steyskal; 1 ♂, near Clarke Hall, Mannett Gutter, July 1, 1964, O. S. Flint, Jr.; 1 ♀, South Chiltern, Feb. 20, 1965, Wirth; 2 ♀♀, Pont Cassé, Oct. 12–14, 1964, Spangler; and 5 miles south of Pont Cassé, Apr. 11, 1964, Flint. The last two specimens represent the pale-legged form.

Merosargus eunomus, new species

FIGURES 3, 6, 9, 10

Close to *M. opaliger* Lindner but readily distinguishable from that species by the black spot on the mesopleuron; also, among other differences, in *M. opaliger* the median frontal vitta is much broader, the abdominal spots on the third and fourth terga are not so discrete, the three stripes forming the presutural extension of the quadrate mesonotal area are brownish, not metallic, and the setose processes of the ninth sternum of the male are not developed. In my key to *Merosargus* (James, 1941, pp. 305–6) *M. eunomus* runs to couplet 27 but, because of the metallic markings of the mesonotum, will not fit either alternative.

MALE.—Frons, vertex, and occiput black; frontal callus white, area between this and antennae, also face, pale yellow. Frons about

0.20 head width, parallel sided to frontal callus, then widening; median area 0.14–0.16 width of frons, longitudinally with irregular striations and in certain lights with greenish reflections; lateral area punctate, each puncture bearing a fine yellow hair; face and frons below callus with fine yellow hairs but without evident punctures; pile of occipital triangle mostly black. Proboscis pale yellow to whitish with concolorous hairs. Antenna orange yellow; scape and pedicel black haired, scape about twice as long as wide; arista subapical, the apex of the flagellum convex below it; arista dark brown to black, thickened and with a few black hairs at base.

Thorax mainly yellow, tending to reddish yellow dorsally; a large shining black quadrate spot on mesopleuron adjacent to notopleural suture; mesonotum with the median two-fifths, behind the suture, metallic green to violaceous, this color extending over the scutellum and produced onto the presutural area of the mesonotum in the form of a narrow median and a pair of dorsocentral stripes, the three becoming more attenuated and sometimes vanishing anteriorly; the extent of the metallic area shows considerable variation, in the extreme instance taking in a considerable part of the median presutural area as well as all of the scutellum and postscutellum. Pile of pleura yellow; that of mesonotum short, black, with a longer, yellowish pile intermixed, consequently the color apparently changing with the light incidence.

Legs predominantly pale yellow; middle tibia broadly blackish at base; hind tibia blackish but with the median half pale yellow to whitish. Wing almost hyaline, slightly smoky; discal cell rather short and blunt, in the holotype 0.63 as wide as long and r-m 0.43 as long as width of discal cell; R_{2+3} arising slightly beyond r-m, bending toward R_1 and running parallel with and close to it to union with costa; alula slender, generally parallel sided, about eight times as long as wide, bare of microtrichia; 15 to 20 hairs on bulbous base of second anal vein but third anal with only pubescence. Halteres yellow.

Abdomen elongate-oval, broadest at apex of fourth segment; basically yellow but with a clear-cut, subquadrate black spot with a distinct violaceous reflection on each side of each of the first four terga; these spots broadly reach the lateral margins but are broadly separated from the abdominal incisures; distance between the two on any one tergum variable but approximately equal to transverse length of spot; fifth tergum with a similar pair of spots but reaching posterior margin and broadly confluent there; first sternum with a black quadrate spot adjacent to each tergal spot of the same segment; sixth segment wholly black, dorsally and ventrally. Pile black dorsally, mostly appressed but becoming semi-erect laterally at incisures, yellow ventrally, mostly appressed. Genitalia (fig. 3) yellow; dististyli broad and somewhat leaflike; aedeagus simple, without evident guards; a pair of

knoblike prominences, each bearing stiff setae, arising apparently from the ninth sternum. Length 4.5–7.5 mm, of holotype 5.5 mm.

FEMALE.—Similar to male except sexually; frons not noticeably wider than in male; fifth tergum black, with the usual violaceous reflections, except a moderately broad anterior margin; sixth segment black only dorsally, with a median apical area yellow. Last segment of ovipositor brownish, a transverse polished area at apex of its tergum; second segment of cercus almost black.

COLOR OF EYE IN LIFE.—Male: Bronzy red in lower half; olive green in upper half, with narrow anterior wedge of indigo (fig. 9).

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE.—♂, Clarke Hall, June 6, 1966, G. Steyskal, type no. 69518, USNM.

ALLOTYPE.—♀, same data but June 8.

PARATYPES.—2 ♀♀, 36 ♂♂, same but May 16 to June 10, Steyskal, and Mar. 11–31, 1965, light trap, W. W. Wirth; 1 ♂, South Chiltern, Feb. 2, 1965, Wirth.

REMARKS.—The name “eunomus” means “orderly,” referring to the neat arrangement of the abdominal spots.

Microchrysa bicolor (Wiedmann)

FIGURES 11, 12

COLOR OF EYE IN LIFE.—Male: Upper, larger ommatidia brick red; lower, smaller ommatidia green with reddish reflections, becoming quite intense green adjacent to upper section (fig. 11). Female: Upper part bronzy reddish; lower part reddish with greenish reflections; slightly above middle with transverse green band, narrowed somewhat posteriorly and bordered above with very dark indigo band and below with narrower deeper green stripe (fig. 12).

DISTRIBUTION.—Throughout the Greater and Lesser Antilles and most of the mainland of tropical America.

I have the following records from Dominica: 9 ♀♀, 1 ♂, Clarke Hall, Jan. 8–31, 1965, malaise trap, W. W. Wirth; 2 ♀♀, 1 ♂, same, June 1964, light trap, O. S. Flint, Jr.; 5 ♀♀, 1 ♂, same, May 16 to June 12, 1966, G. Steyskal; 1 ♂, same, Feb. 10, 1965, reared banana stem, Wirth; 1 ♂, same, Jan. 22, 1964, H. Robinson; 1 ♀, Hillsborough Estate, Mar. 15, 1965, Wirth.

Artemita inornata (Williston)

Kertész (1914) did not know this species and doubted its distinctness from *Acanthina bellardii* Giglio-Tos on the basis that the reddish color of the scutellum in the latter species may not be diagnostic. I have identified both *Artemita inornata* and *Acanthina bellardii* from Mexico, and the two are quite distinct; the red scutellum of *Acanthina*

bellardii stands out in strong contrast to the color of the thorax and abdomen and is not merely a reddening of certain integumentary areas, as is so often the case. There are a number of other differences between the two, but *Artemita inornata* seems most closely related to *Acanthina bellardii*. One morphological peculiarity that the two have in common is the presence of a polished depressed area at the base of the anteroventral surface of the hind tibia. This does not occur in the other species of *Artemita* known to me nor in the related genera *Spaniomyia*, *Acanthinomyia*, and *Cibotogaster*.

The reference of *Acanthina inornata* to *Artemita* is quite clear even though this species will trace only imperfectly to that genus in the keys of Kertész (1914, 1916) and Lindner (1964). The scutellum is on a plane with the mesonotum, as in *Acanthinomyia*, and without a deep groove separating them, but the mesonotum is not flattened, as in *Acanthinomyia*, and the other characters of significance, as well as the general appearance, are those of *Artemita*. In *Acanthina bellardii* the incision between the scutellum and the mesonotum is likewise shallow, not much more noticeable than in *Artemita inornata*.

Because of the brevity of Williston's description and the fact that the illustration accompanying it is erroneous in at least two respects (antennal and scutellar structure; cf. Kertész, 1914), and because of the vagueness in such respects as the description of the mesonotal and abdominal pattern, the females from Dominica are described herein in detail.

FEMALE.—Occiput except orbits and broad lateral margins and genae except orbits black, head otherwise yellow, becoming reddish yellow on upper occipital orbits and margin, cerebrale, midfrontal line, and lower frons and face. Frons at narrowest about 0.14 head width, widening to about 0.20 head width at vertex and also to about 0.20 head width at frontal callus, thence broadening abruptly to face. Eyes with moderately dense and long pile; pile mostly yellow but prominently black above. Pile of head yellow. Antenna very similar to that of *Artemita convexa* Walker or *Artemita aurata* Macquart (cf. Kertész, 1914, fig. 28), but terminal flagellar segment slightly longer and more slender; scape and pedicel reddish yellow, flagellum reddish at base, gradually becoming black toward apex; first three flagellomeres with whitish sensoria against the darker background; apex of flagellum with three or four erect hairs. Proboscis black.

Thorax black with whitish to yellowish appressed pile; mesonotum with three longitudinal vittae that lack this pile and have instead inconspicuous black pile, the outer vittae reaching the corners of the scutellum but widely separated from the humeri, the median one broad and running from anterior margin of mesonotum to base of scutellum, from anterior view interrupted by a median vitta of golden

pile; mesopleura and sternopleura with some black semi-appressed hairs, the pleural pile otherwise pale and mostly tomentum-like. Scutellum almost on a plane with mesonotum, the groove separating them shallow; scutellum moderately convex, well margined; spines fairly robust, finger-like, blunt apically and tending to turn toward the median line. Wing venation similar to that of *Artemita peruviana* (cf. Kertész, 1914, fig. 32); base of R_s weakened; part of M separating basal cells largely reduced to a fold; wing wholly hyaline except yellow stigma; microtrichia greatly reduced in area covered, wholly lacking in cells R_3 and R_4 , reduced to a small patch in the discal cell, lacking in large part on anterior half of wing but much better developed at apex and posterior part, including entire alula. Halteres yellow. Legs black, only the knees reddish yellow.

Abdomen black; fourth tergum either wholly black or with irregularly outlined reddish patches; first and second terga with short erect whitish hairs; second to fifth terga with lateral patches of whitish tomentum, small on second, much larger on third, taking up all of fourth except a medial basal and a pair of sublateral apical triangular patches and all the fifth except a narrow median vitta; some erect scattered black pile intermixed with yellow on fourth and fifth terga. Apical third of fifth tergum abruptly bowed upward, polished medially, rugulose and with erect black hairs on its posterior margin. Venter black; first sternum with thick, short tomentum with a copperish hue; other sterna with scattered whitish appressed hairs. Ovipositor with intermediate segments prominently striated transversely. Length 5.0–5.5 mm.

DISTRIBUTION.—Extreme southern Texas, Mexico, Dominica.

I have the following record from Dominica: 3 ♀♀, Clarke Hall, Mar. 21–31, 1965, malaise trap, W. W. Wirth.

REMARKS.—The species was described from the State of Veracruz, Mexico. I have specimens from Donna, Tex., in the lower Rio Grande Valley and from the Mexican states of Tamaulipas, Nayarit, and Oaxaca. There is no significant difference between the Mexican and the Dominican females. This discontinuous distribution can be explained most satisfactorily in one of two ways, either from our ignorance of the true distribution of the species or on the assumption that it was introduced from Mexico (or at least the Central American mainland) into the Lesser Antilles.

Psephiocera marginata, new species

FIGURES 13, 20

FEMALE.—Entirely black except antennae, legs, wings, halteres, and ovipositor. Head 0.70 as long as high, subglobose; ocellar triangle low in profile; occipital orbits very narrow. Vertex in holotype 0.26

head width, frons narrowing gradually to 0.14 head width at callus, then widening onto face; frons above callus and vertex shining, with very sparse, microscopic white hairs; lower part of frons and face, particularly facialia, densely white tomentose, becoming somewhat yellowish below. Flagellum large, 1.5 as high as long, kidney shaped from inner view; apical half of flagellum blackish; arista black; antennae otherwise yellow. Proboscis brownish black with concolorous hairs.

Mesonotum with appressed brassy-yellow hairs, well distributed but relatively sparse and not conspicuous; supra-alar prominences and scutellum except base with similar black hairs; posterior bulge of mesopleuron and sternopleuron with scattered semi-erect white hairs, rest of mesopleuron and pteropleuron bare and shining. Scutellum (fig. 20) overall triangular, the effect accentuated by the distinctly margined, slightly upturned, flattened apical part, which takes in about one-third the length of the scutellum; entire sides of margined area beset with microdenticles. Legs wholly pale yellow, the femora on apical half slightly tending to brownish yellow. Halteres yellow, brownish on basal part of knob. Wings hyaline; heavier veins yellow, brownish on basal half; venation similar to that of *Meristocera laticornis* (fig. 15), but all veins except part of M separating discal cell distinct throughout; R_{2+3} , however, distinct throughout, though feeble, and branching from R_s at cross-vein; cross-vein r m distinct but short; anal cell narrower than combined width of basal cells; and R_s more strongly evanescent at base. More than half of anal cell clothed with microtrichia.

Abdomen gradually expanding to base of third segment, thence rounded; area of denser punctures extending to apical part of fourth tergum, the fifth and sides of third and fourth broadly shining; venter with first sternum and sides of second densely punctured. Ovipositor yellow. Length 2.50–2.75 mm.

MALE.—Unknown.

COLOR OF EYE IN LIFE.—Female: Broad upper area reddish purple, crossed above middle with somewhat arcuate bronzy-green band that runs into similarly colored lower part of eye at rear (fig. 13).

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE.—♀, Clarke Hall, June 6, 1966, G. Steyskal, type no. 69519, USNM.

PARATYPE.—♀, Antrim, 1000 ft., March 1956, J. F. G. Clarke.

Psephiocera callosa, new species

FIGURE 19

FEMALE.—Wholly black except antennae, legs, halteres, wings, and ovipositor. Head 0.82 as long as high; ocellar triangle low in

profile; occipital orbits very narrow. Vertex in holotype 0.27 head width, narrowing gradually to 0.18 head width at callus, then widening onto face; frons above callus subshining, somewhat rugulose, an elongated triangular, elongated sublateral area on each side toward callus shining; punctures and pile sparse; lower part of frons and face, particularly facialia, densely white tomentose; a rounded, depressed area above antennal bases, however, polished. Antennal flagellum of moderate size, 1.5 as high as long, transverse basally on inner side; flagellum brownish black on apical half, on inner side toward apex with a polished semilunar callus similar to that of *Neopachygaster* species but not so prominent; arista brownish, antenna otherwise yellow. Proboscis brownish black with concolorous hairs.

Mesonotum with brassy yellow hairs as in *P. marginata* but relatively dense and more conspicuous, especially before the scutellum; laterally before the suture these become yellow and are arranged longitudinally in about four irregular rows; some black appressed hairs on supra-alar prominences, anterior margin of mesonotum, and apex of scutellum; disc of scutellum with hairs as on mesonotum but not so conspicuous. Scutellum rounded, two-thirds as long as wide, prominently margined but margin not flattened and subparallel to discal part of scutellum and extending laterad a considerable distance (fig. 19); margin with a row of microdenticles. Legs wholly yellow. Wing essentially as in *P. marginata* but interruption of R_s at its base is not so prominent and R_{2+3} may arise either at or a little before r-m. Abdomen as in *P. marginata*. Ovipositor yellow. Length 2 mm.

MALE.—Unknown.

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE.—♀, Clarke Hall, Jan. 8–10, 1965, malaise trap, W. W. Wirth, type no. 69520, USNM.

PARATYPES.—2 ♀♀, same but Jan. 21–31 and Feb. 11–20.

The two species of *Psephiocera* described above will trace to paragraph 51 of Lindner's (1964) key to the Neotropical Pachygastrinae. In the two species following this paragraph, *Cyclotaspis inornata* Lindner and *Myiocavia tomentosa* Lindner, the height of the head in proportion to its length is 1.75–2.00, much greater than in *Psephiocera*, and the position of the antennal bases is much lower. If one disregards the point of origin of R_{2+3} , a character that is subject to some variation in the Pachygastrinae, and chooses paragraph 54 instead of 35, both species trace to paragraph 88, but below that one gets into difficulty. On the basis of the structure of the antennae and scutellum, *P. marginata* would trace to *Clarissa pallipes* Lindner but the white arista used as a supplementary key character contradicts the arista coloration in *P. marginata*; comparison with a para-

type of *C. pallipes* indicates other outstanding differences, for example, the much less strongly margined scutellum and the wholly reddish yellow flagellum. On the basis of the rounded scutellum, *P. callosa* traces to *Lasiodeictes niger* Lindner except for the black scutellar vestiture of that species.

Lindner keys three *Psephiocera* species with wholly yellow legs. *P. marginata* and *P. callosa* differ from all of these, according to the descriptions, in scutellar structure. The callosity on the antennal flagellum of *P. callosa* is apparently unique in this genus, so far as the known species are concerned. Comparison of *P. marginata* and *P. callosa* with *P. flavipes* Enderlein, the type of the genus, shows a number of differences; for example, the pleura of *P. flavipes* are almost wholly bare and shining and the weaker wing veins are reduced almost to folds, as in *Meristocera laticornis*. *Psephiocera metzi* Johnson from Jamaica, another yellow-legged species that is not included in Lindner's key, is described as having three stripes of yellowish-white tomentum on the mesonotum; in *P. callosa* and *P. marginata* the mesonotum certainly is not striped.

The value of the origin of R_{2+3} from the radial sector should be discounted as a generic character. It can often be used to good advantage, but there are a number of situations in which it can not be used. These include cases in which the radial sector bows gradually after its origin from vein R (cf. fig. 15) in contrast to those in which the sector is bent abruptly at cross-vein r-m (cf. fig. 16). In the former group, R_{2+3} is often weak or even evanescent, so that its origin may be indeterminable; even when it is determinable, it may be variable. Considerable study needs to be made of venational characters in the *Pachygaster*-like *Pachygastrinae*.

Meristocera laticornis, new species

FIGURES 14, 15

The genus *Meristocera* Lindner was based on a single species, *M. aurea* Lindner, from Santa Catarina, Brazil. The Dominica species is very similar, according to Lindner's description, but can be distinguished readily by the structure of the antenna, the flagellum in *M. laticornis* being much broader and more distinctly triangular.

FEMALE.—Black, with antennae except above, proboscis, legs including coxae, halteres, heavier wing veins, and cerci bright yellow. Frons about 0.25 head width and parallel sided above callus (described as one-third head width and narrowing above in *M. aurea*); vestiture as described for *M. aurea*. Flagellum blackish above, the sensoria large, prominent in the darkened area because of their contrasting yellow coloration; pedicel on inner side extending strongly into flagellum as in *M. aurea*. Vesture of thorax as described for *M. aurea*.

Wing hyaline, uniformly clothed with microtrichia except at extreme base, including basal part of anal cell; alula completely with microtrichia and with a long posterior fringe; veins forming discal cell except at base weak; part of M separating basal cells weak, evanescent at base; R_{2+3} weak, almost evanescent, at base, but arising well beyond r-m, which is short, almost punctiform (fig. 15). Densely punctate area of abdomen extending over basal half medially of fourth tergum, the punctures becoming more spaced laterally and toward fourth tergum; first sternum and extreme sides of second closely punctate, as toward base of abdomen dorsally, abdomen otherwise shining. Length 2.25 mm.

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE.—♀, Clarke Hall, Aug. 9–15, light trap, T. J. Spilman, type no. 69521, USNM.

Dactylodeictes depressus, new species

FIGURE 5

MALE.—Wholly black except antennae, legs, halteres and wings. Head similar in profile to that of *D. lopesi* Lindner (1964, fig. f) but not so high, about 1.7 as high as long (2.0 in *D. lopesi*; ocellar triangle not prominent. Frons barely wider than ocellar triangle at same plane and becoming narrower below, at narrowest about 0.13 head width; a prominent rounded pit between callus and antennal bases; callus small, polished, a narrow polished area extending from it to anterior ocellus; sides of frons above callus, frons below callus except frontal pit, and face with dense white tomentum. Occipital orbits narrowly developed below, densely white tomentose. Antennae yellow, flagellum and arista reddish yellow, flagellum on inner surface with a conspicuous, polished, brownish-black, crescentic spot. Proboscis brownish black.

Mesonotum and basal half of scutellum with fine, pale yellow appressed hairs; a pair of triangles extending on each side of median line almost to suture and leaving a narrow mid-dorsal presutural vitta, also a pair of rounded postsutural spots in line with these triangles, black haired; sides of mesonotum before suture with conspicuous, larger yellowish hairs arranged in irregular longitudinal rows, the integument in these areas more conspicuously shining than elsewhere on the mesonotum. Scutellum elevated at an angle of 45° with mesonotum, margined, microdenticulate on apical half, terminating in a bluntly rounded digitate process that is slightly longer than wide and that extends in a plane with the scutellum; apical half of scutellum with black hairs. Pleura yellow haired. Legs yellow; each femur with a preapical brownish band and foretibiae more or less brownish. Wing hyaline; veins brown; stigma yellow. R_s vestigial basally;

part of M separating basal cells reduced to a fold. R_{2+3} arising at r-m. Microtrichia generally distributed except at extreme wing base, including largest part of anal cell; alula broadening somewhat toward apex, where it is rounded, completely beset with microtrichia. Halter with yellow stalk and white knob.

Abdomen largely black haired, some whitish erect pile mixed with black at sides of basal two segments; terga 3 and 4 each with a side spot of appressed whitish hairs, small on 3 but large on 4; a median vitta of whitish hairs running from middle of third tergum to apex of abdomen. Sternum wholly with inconspicuous black hairs. Genitalia small; aedeagus (fig. 5) trifid, the intromittent organ and guards similar in form, digitate and rounded apically; dististyli rather robust, oval. Length 3.0–3.5 mm.

FEMALE.—Frons distinctly broader than ocellar triangle, at narrowest 0.19–0.20 head width, median polished area proportionately narrower and sides of frons not so densely tomentose. Occipital orbits very narrowly developed on upper half and not tomentose, on lower half slightly broader than in male. Dorsal hairs of mesonotum more brassy; black hairs more extensive, the pair of triangles extending to form a presutural vitta confluent with the postsutural spots as well as with a pair of presutural spots, thus tending to isolate the median area into a presutural vitta of yellow hairs.

DISTRIBUTION.—Dominica, Lesser Antilles.

HOLOTYPE.—♂, Clarke Hall, Jan. 21–31, 1965, malaise trap, W. W. Wirth, type no. 69522, USNM.

ALLOTYPE.—♀, same.

PARATYPES.—1 ♂, 18 ♀♀, same but Jan. 11 to Mar. 31; 1 ♀, Hillsborough Estate, Mar. 13, 1965, H. E. Evans.

This species is apparently very close to *D. lopesi* Lindner. There are a number of small differences: the head proportions, the mesonotal pattern, the darkened anterior tarsus. *Dactylodeictes amazonicus* Kertész, the type of the genus, is easily differentiated by the elevated ocellar triangle, and *D. insularis* James, from the Galápagos, by the lack of differentiated lateral hairs on the mesonotum, the longer and more erect digitate process of the scutellum, and the lack of a differentiated vitta of hairs on the abdomen. Lindner and Kertész make no mention of the differentiated lateral, presutural hairs. What I take to be *D. lopesi* Lindner, based on a male from the Canal Zone and two females from Trinidad, has the mesonotal pile much coarser, covering the mesonotum except for a pair of spots on the postsutural prominences and a pair of inward extensions from the anterior margin, and without lateral differentiation of hairs; this agrees with Lindner's description.

Pachygaster wirthi, new species

FIGURES 4, 16-18

MALE.—Head (fig. 17) about as long as high; eyes large, contiguous most of way from ocellar triangle to frontal triangle, upper facets much larger than lower but with no sharp line of demarcation; frontal triangle distinctly and deeply depressed below level of eyes; face likewise depressed but not so clearly so, concave in transverse profile; postgenal area prominent, occipital orbits evanescent above; occiput somewhat concave transversely above. Head black, largely shining, pile yellow, that on most of occiput very short and inconspicuous, black; sides of face whitish tomentose, this tomentum ending at antennal bases. Antennae orange yellow, arista black to blackish. Proboscis pale yellow.

From lateral profile, anterior dorsal angle of thorax prominent; scutellum approximately on plane with mesonotum, rounded, without margin or notches, microdenticulate along border. Thorax black; mesonotum and scutellum regularly clothed with golden tomentum, which is conspicuous but by no means conceals the background; pile on pleura more whitish and largely semi-erect; large polished bare areas on mesopleuron and pteropleuron. Legs yellow and yellow pilose, at most base of hind coxa brownish; apical tarsomere of each leg slightly brownish yellow. Wing somewhat infumated, stigma yellowish brown; sides of discal cell almost parallel (fig. 16); part of M separating basal cells feeble, its base evanescent; R_{2+3} arising well before r-m; basal part of R_{4+5} angularly bent at r-m. Microtrichia lacking only at extreme base, including basal half of anal cell; alula completely clothed with microtrichia. Halter yellow, knob becoming whitish.

Abdomen oval, about 1.7 as long as maximum width, widest near apex of second segment; densely punctured dorsally, the punctures confluent, the broad sides beyond apex of second abdominal tergum, however, shining, this area extending inward somewhat along the incisures and forming a complete apical margin on terga 4 and 5; the polished area bearing blackish, semi-erect pile; an irregular row of impressed, rounded punctures, quite distinct and much larger than those of the densely punctate area, along each of the tergal incisures. Venter black, shining, with scattered black pile; a large part of first sternum and extreme sides of second and third with fine punctures that are close together but not confluent, as on the dorsum. Genitalia slender, mostly brownish to blackish; aedeagus (fig. 4) trifid, the guards divergent apically; dististyli slender, acute apically. Length 3.0-3.5 mm.

FEMALE.—Head (fig. 18) shorter proportionately than in male; frons at narrowest 0.25 head width, widening to 0.40 head width at vertex; frons depressed below callus but not deeply so as in the male; occipital orbits well developed throughout. Frons with yellow pile. Antennal flagellum longer than in male. Abdomen nearly round, not more than 1.1 as long as wide, the shining area much more extensive and including all of fifth and posterior half of fourth tergum, as well as a broader lateral area. Ovipositor yellow.

DISTRIBUTION.—Dominica and Antigua, Lesser Antilles.

HOLOTYPE.—♂, Hillsborough Estate, Mar. 15, 1965, W. W. Wirth, type no. 69523, USNM.

ALLOTYPE.—♀, same but Mar. 13, 1965, H. E. Evans.

PARATYPES.—58 ♂♂, 20 ♀♀, same as holotype and allotype; 8 ♂♂, 3 ♀♀, Layou River mouth, Mar. 8, 1965, Wirth; 5 ♂♂, Clarke Hall, Feb. 20–28, 1965, Evans; 3 ♀♀, same, malaise trap, Mar. 8, 1965, Wirth; 2 ♂♂, 5 ♀♀, South Chiltern, Feb. 6 and Mar. 25, 1964, H. Robinson, and Dec. 8–10, 1964, P. J. Spangler, and Feb. 20, 1965, Wirth; 1 ♂, Antigua, St. Johns, Mar. 11, 1965, Evans; 1 ♀, Antigua, English Harbor, Apr. 20, 1958, J. F. G. Clarke.

The generic reference is made only provisionally and with the realization that ultimately it will have to be changed. A critical study of the genera of small, black *Pachygaster*-like Pachygastrinae is needed badly. The simplest thing to do would be to refer this species to a new genus, which it probably is, but it is certainly more like the Nearctic species of "*Pachygaster*" than they are like the type of the genus, *P. arta* Panzer. True *Pachygaster* probably does not occur in America.

In Lindner's (1964) generic key, this species traces to *Cyclotaspis*; the head in *C. inornata* Lindner, the type of the genus and the only known species so far, is distinctly higher than wide and the abdominal pile is erect. In my key (James, 1965) to the Nearctic genera it traces to *Pachygaster*; the venation is quite similar to that of *P. pulchra*, but that species has a much more differently shaped head and abdomen and, among other things, lacks the golden mesonotal tomentum. In *P. cazicri* James, from South Bimini, Bahamas, also placed only provisionally in this genus, the venation is much different, R_{2+3} arising well beyond cross-vein r-m. *Lyprotemyia formicaformis* Kertész has many structural similarities with *P. wirthi*, but it can be distinguished readily by the long, hornlike apical prolongation of the scutellum. *Pachygaster wirthi* will not trace through the Kertész (1916) key because of a blind pocket in that key.

Chalcomorphina planes, new species

Clearly congeneric with *C. aurata* Enderlein, the type and only known species in the genus, but differing in a number of respects, including the following: the vertex of the female is not elevated, as in *C. aurata*; the antennae, and particularly the scape, are shorter; the extent of the golden mesonotal pile of the female is much less extensive; and the scutellum is much more nearly on a plane with the mesonotum, with the apical part, particularly in the female, much less robust.

FEMALE.—Entirely black except antennae, legs, wings, halteres, and ovipositor. Head structurally similar to that of *C. aurata* but longer, the frons narrower, occiput not so distinctly concave, vertex and ocellar triangle not unusually elevated, face not projecting at antennal bases, and proportions of antennae different. Comparative ratios in holotype of *C. planes* and (in parentheses) a female *C. aurata* from Peru: head length to head height 0.63 (0.52 excluding, 0.48 including, ocellar triangle); frons at narrowest and at vertex, respectively, to head width 0.14, 0.19 (0.21, 0.25); antennal length to head length 1.18 (1.66); scape to entire antenna 0.33 (0.48). Frontal callus defined only by a narrow transverse impression, area above this completely shining, below with orbits extending to lower eye margin densely yellow tomentose, leaving median part of lower frons shining, middle of face, however, not shining and with scattered, appressed whitish hairs; gena shining; occipital orbits not developed. Mesonotum with golden tomentum as in *C. aurata*, but more limited in extent; this tomentum forming a median longitudinal vitta, a narrow cross-band just before the suture and another in front of scutellum and extending from one supra-alar region to the other, also basal half of scutellum golden tomentose; lateral presutural area shining, broadly set with about eight irregular rows of appressed yellow hairs, these merging into a small patch of tomentum medio-anteriorly, above the humerus; rest of mesonotum opaque and with appressed black hairs and tomentum. Pleura as in *C. aurata*, mostly bare and shining above except a patch of appressed white hairs on mesopleura, below mostly with white hairs. Scutellum at but a slight angle, not more than 15°, with mesonotum (about 60° in *C. aurata*), structurally as in *C. aurata* but not so robust. Legs wholly yellow. Halteres with brownish-yellow stalk and whitish knob. Wing hyaline; venation as in *C. aurata* and similar to that of *Meristocera* (fig. 15), but veins except part of M separating basal cells mostly distinct, not mere folds; cross-vein r-m either wanting or distinct and very short, the same variability in this respect occurring in *C. aurata*; M_{2+3} arising distinctly beyond r-m; wing set with microtrichia except at extreme base; alula more acute apically than in *Meristocera*, completely beset

with microtrichia. Abdomen black, mostly with whitish and fairly dense but inconspicuous, appressed hairs; densely punctate area extending onto basal part of fourth tergum; first sternum and sides of second, as usual, very densely punctate. Ovipositor mostly brownish yellow, terminal segment and cerci a clearer yellow. Length 1.60-2.25 mm.

MALE.—Eyes contiguous almost half way from anterior ocellus to antennal base. Frontal triangle shining medially, as in female. Presutural lateral areas of mesonotum with silvery hairs, arranged in irregular rows as in the female; rest of mesonotum and base of scutellum with dense, silvery, appressed tomentum-like hairs that conceal the background. Hind femur brownish yellow on median third. Abdomen with semi-erect lateral whitish hairs basally. Otherwise, except sexually, as described for the female.

HOLOTYPE.—♀, Clarke Hall, Jan. 21-31, 1965, malaise trap, W. W. Wirth, type no. 69524, USNM.

ALLOTYPE.—♂, same but Jan. 11-20. The male genitalia have been distended and are damaged to the extent that I can not make out any structural details; otherwise, the specimen is in good condition.

PARATYPES.—3 ♀♀, same as holotype and allotype.

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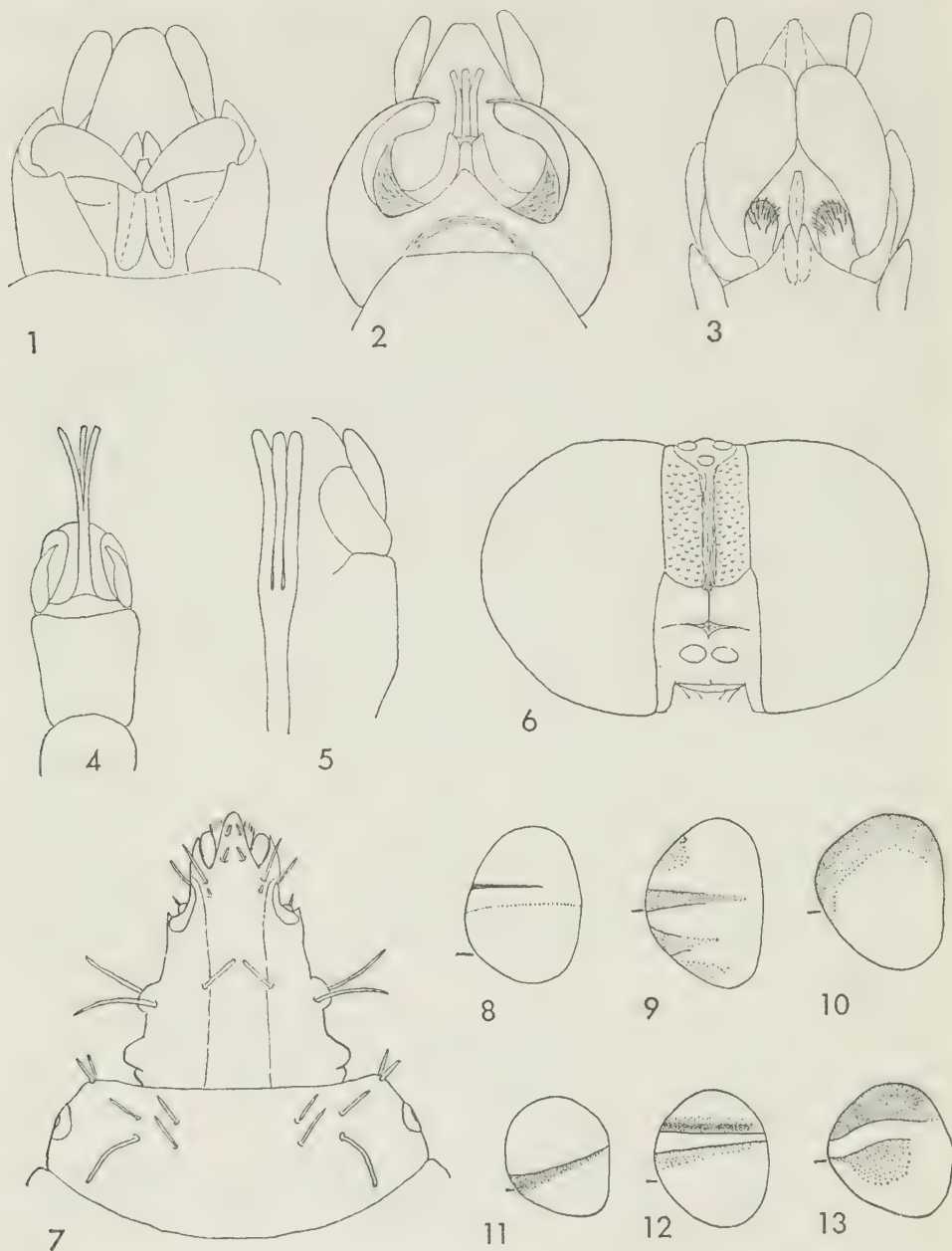
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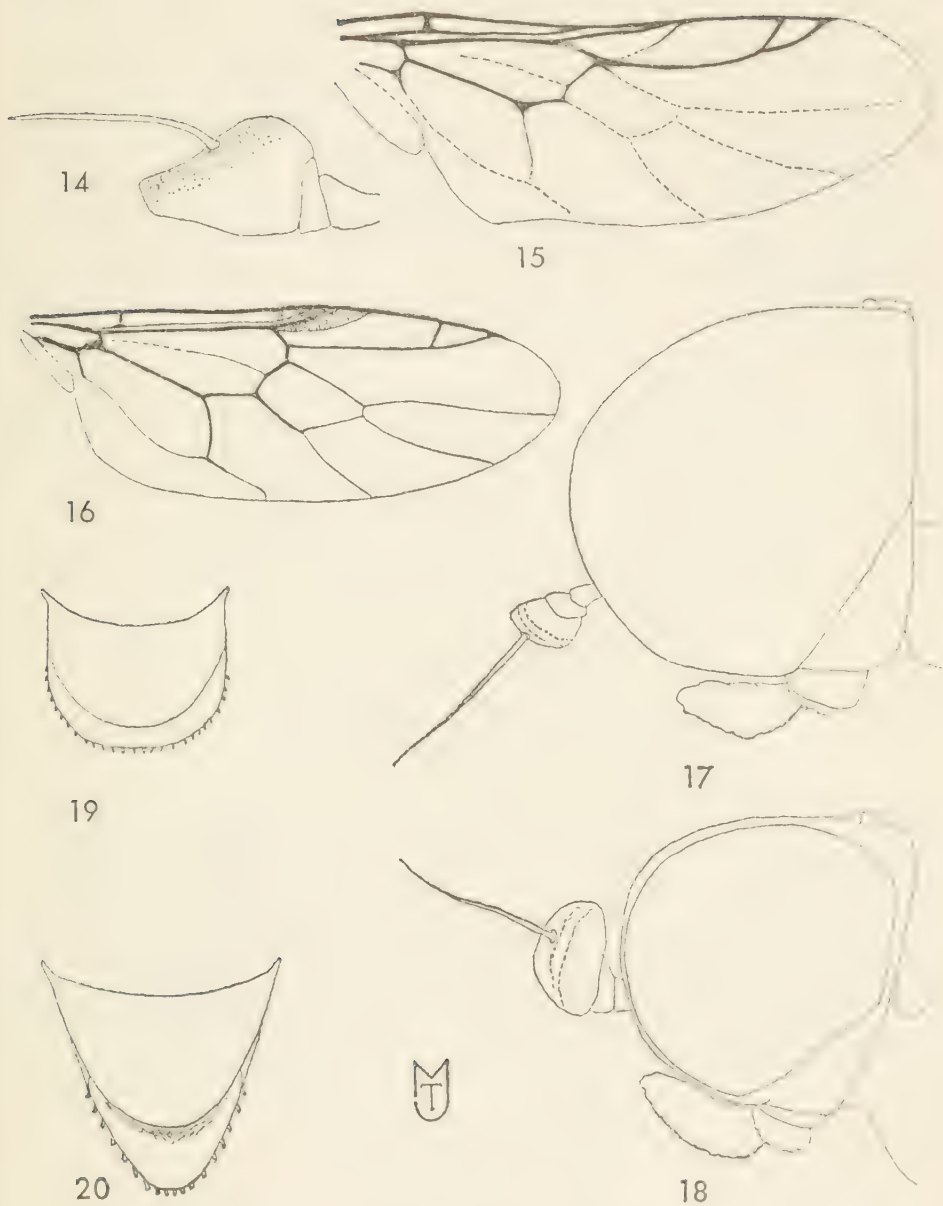
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FIGURES 1-13.—Male genitalia, ventral view: 1, *Cyphomyia dominicana*, new species; 2, *Pelagomyia illucens*, new species; 3, *Merosargus eunomus*, new species; 4, *Pachygaster wirthi*, new species; 5, *Dactylodeictes depressus*, new species, aedeagus (left) and dististyli and cerci (right). Head, anterior view: 6, *M. eunomus*, new species. Head and prothorax of puparium: 7, *C. dominicana*, new species. Pattern of eye color in life (position of antennae indicated by dash): 8, *C. dominicana*, new species, female; 9, *M. eunomus*, new species, male; 10, same, female; 11, *Microchrysa bicolor* (Wiedemann), male; 12, same, female; 13, *Psephiocera marginata*, new species, female. (Figs. 8-13 by G. C. Steyskal.)



FIGURES 14-20.—*Meristocera laticornis*, new species: 14, antenna; 15, wing. *Pachygaster wirthi*, new species: 16, wing; 17, head of male, lateral view; 18, head of female, lateral view. Scutellum: 19, *Psephiocera callosa*, new species; 20, *P. marginata*, new species.

Proceedings of the United States National Museum



SMITHSONIAN INSTITUTION • WASHINGTON, D.C.

Volume 123

1967

Number 3623

Caritus, a New Genus of Caligoid Copepod, With a Key to the Genera of Caliginae

By Roger F. Cressey

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A small collection of copepods parasitic on *Chanos chanos* (Forskål), the milk fish, from Nosy Bé, Malagasy Republic, has brought to light a new genus of caligoid copepod described herein. The copepods were collected during the author's participation in the International Indian Ocean Expedition and he acknowledges the National Science Foundation-U.S. Program in Biology for supporting the field portion of this work. All material has been deposited in alcohol in the U.S. National Museum. All drawings were made with the aid of a camera lucida.

CALIGIDAE: CALIGINAE

Caritus, new genus

First 3 thoracic segments fused with head. Fourth thoracic segment free. Lunules present. Dorsal plates absent. Postantennal process (maxillary hook) and sternal furca absent. First antenna 2-segmented. Second antenna with well-developed claw. Maxilliped with strong claw. Legs 1-3 biramose. Leg 1 exopod 2-segmented, endopod rudimentary, 1-segmented. Leg 2 with both rami 3-segmented. Leg 3 exopod 3-segmented, endopod 2-segmented. Leg 4 uniramous, exopod 3-segmented. Leg 5 present. Leg 6 present in male only. Genital segment

of typical caligoid form. Abdomen 1-segmented. Caudal rami conspicuous. Egg strings uniseriate.

Diagnosis applies to both sexes except where noted.

TYPE-SPECIES.—*Caritus serratus*, new species.

ETYMOLOGY.—From Latin, masc., "lacking, devoid of," alluding to lack of postantennal process and sternal furca.

Caritus serratus, new species

MATERIAL STUDIED.—4 females, 1 male from the gills of 2 specimens of *Chanos chanos* (Forskål) collected at Nosy Bé, Malagasy Republic, April 1964. Holotype female, USNM 120352. Allotype male, USNM 120353. Three paratype females, USNM 120354. One paratype female dissected for study.

FEMALE.—Body form as in figure 1. Total length and greatest width (measured at cephalon) of 3 undissected specimens 5.1 x 2.2 mm, 5.0 x 2.3 mm, and 4.3 x 1.9 mm. Cephalon comprising nearly one-half of body length, about as wide as long. Genital segment markedly triangular; narrowest anterior, widest posterior, about as long as wide (1.7 x 1.7 mm in 1 specimen). Abdomen 1-segmented (1.2 x .46 mm in 1 specimen); widest near middle, tapering only slightly to proximal and distal ends with slight constriction near distal end. Caudal rami (fig. 2) lamelliform; about 3 times as long as wide (420μ x 147μ in 1 specimen), bearing 6 short, naked setae arranged as in the figure.

First antenna (fig. 3) 2-segmented; first segment bearing numerous stout plumose setae along anterior margin, 2d segment bearing fewer naked setae near distal tip. Second antenna (fig. 4) 4-segmented; terminal segment in form of a stout claw, armed with 2 small setae as in figure. Mouth tube and mandible of usual caligoid form. Mandible with 12 teeth at tip. First maxilla (fig. 5) consisting of strong post-oral process and basal lobe bearing 3 naked setae. Second maxilla 2-segmented; tip of last segment as in figure 6. Maxilliped (fig. 7) in form of stout claw.

Legs 1-3 biramose. Leg 1 (fig. 8) with inner and outer short plumose setae on basipod; exopod 2-segmented armed as in figure, endopod 1-segmented with very small spine on inner distal corner. Inner 3 setae on last exopod segment plumose as in figure 9. Leg 2 (fig. 10) rami 3-segmented. Spines on outer distal corners of first 2 segments of exopod conspicuously toothed on inner margins, large distal spine on terminal segment with broad hyaline border. Leg 3 (fig. 11) coxobasipod forming a broad lamella, rami small. Exopod 3-segmented without setae; spine on outer distal corner of first segment prominent, others reduced as in figure. Endopod 2-segmented; each segment

unarmed except for a fringe on outer border of each, ramus held along edge of basipod. Leg 4 (fig. 12) uniramous; exopod 3-segmented, each segment armed as in the figure, each segment with a fringe overlapping the bases of each spine. Spine and setal formula of legs 1-4 follows (Roman numerals refer to spines, Arabic to setae):

	leg 1		leg 2		leg 3		leg 4	
	exo	end	exo	end	exo	end	exo	end
seg 1	I:0	I	I:0	0:1	I:0	0	I:0	
seg 2	IV:3		I:I	0:2	I:I	0	I:0	
seg 3			III:5	6	IV		III	

All setae on legs 1-5 plumose. Leg 5 (fig. 13) a single free segment bearing 3 terminal setae, additional basal seta on inner lobe. Leg 6 absent. Egg strings uniseriate, long (2.9 mm in 1 specimen).

MALE.—Body form as in figure 14. Total length 4.6 mm. Greatest width 2.0 mm (all measurements based on 1 specimen). Cephalon as long as wide (2.0 x 2.0 mm). Genital segment rounded, somewhat longer than wide (1.1 x .9 mm). Abdomen about 3 times as long as wide (1.45 x .45 mm), widest in posterior half. Caudal rami (fig. 15) about twice as long as wide (478μ x 217μ) bearing 6 setae, inner and outer subterminal small and naked, terminal 4 stout and plumose, inner margins of rami with row of short hairs.

Cephalic and thoracic appendages as in female with following exceptions: Leg 2 exopod terminal segment proximal spine toothed (naked in female). Leg 3 exopod (fig. 16) with 7 spines on terminal segment (4 in female), inner distal corner of second segment with short plumose seta (short spine in female). Leg 5 (fig. 18) represented by 4 plumose setae located at lateral sclerotized notch near mid-edge of genital segment. Leg 6 (see fig. 18) represented by 2 naked setae at outer distal corner of genital segment. Spermatophores rounded, visible within genital segment.

ETYMOLOGY.—From Latin, masc., "serrated," alluding to the toothed nature of the exopod spines of leg 2.

The Genera of Caliginac

The genus *Caritus* can be separated from all genera of the Caliginac except *Echetus*, *Alicaligus*, *Scianophilus*, and *Abasia* by the absence of both the postantennal process (maxillary hook) and sternal furca. It can be separated from these 4 genera because they all have a fourth leg exopod of only 2 segments (*Caritus* has 3). Not enough information was available to the present author to make a thorough comparison with *Caligopsis* Markewitsch but, according to the generic diagnosis given by Yamaguti (1963), the fourth legs are absent in *Caligopsis* (thus distinguishing *Caritus* from it).

Pillai (1962) erected a new genus *Pseudopetalus* to accommodate *P. formicoides* and *P. caudatus*, which he showed to be generically different from other species of *Parapetalus*, the genus to which they formerly belonged. He also proposed a new genus, *Parechetus*, to include *P. carangis*, formerly assigned to the genus *Caligodes*. Further, in 1963, in considering the genus *Abesia*, he showed that members of this group possess lunules, thus conforming to the requirements for inclusion in the subfamily Caliginae. Ho (1966) points out Yamaguti's error in erecting a new subfamily for *Echetus* since the genus does possess frontal lunules and therefore should be assigned to the Caliginae. These recent works, plus the new genus described herein, bring the total number of genera in this subfamily to 13. Since Yamaguti's key to the genera of Caliginae includes only 8 genera, his key is now inadequate and a new key is provided below to include the 5 additional genera.

Key to Genera of Caliginae Females

1. Sternal furca present 2
Sternal furca absent 9
2. Postantennal process (maxillary hook) absent 3
Postantennal process present 4
3. Fourth leg exopod 2-segmented, leg 1 with rudimentary endopod. **Caligodes**
Fourth leg exopod 3-segmented, leg 1 endopod absent **Parechetus**
4. Leg 4 rudimentary or absent 5
Leg 4 normal 6
5. Leg 4 absent **Caligopsis**
Leg 4 consisting of small knob with 2 or 3 setae **Pseudocaligus**
6. Body form typical caligoid form with no elongations or prominent winglike processes **Caligus**
Body form elongate or with conspicuous winglike processes 7
7. Leg 4 exopod 2-segmented **Pseudopetalus**
Leg 4 exopod 3-segmented 8
8. Genital segment produced posteriorly to form 4 digitiform processes. **Synestius**
Genital segment and abdomen with prominent lateral expansions. **Parapetalus**
9. Leg 4 exopod 3-segmented **Caritus**
Leg 4 exopod 2-segmented 10
10. Leg 1 endopod 2-segmented **Sciaenophilus**
Leg 1 endopod 1-segmented 11
11. Leg 3 exopod 2-segmented **Alicalgus**
Leg 3 exopod 3-segmented 12
12. Cephalic region separated from genital segment by long neck . . . **Echetus**
Body of more usual caligoid form, rostral area distinct **Abasia**

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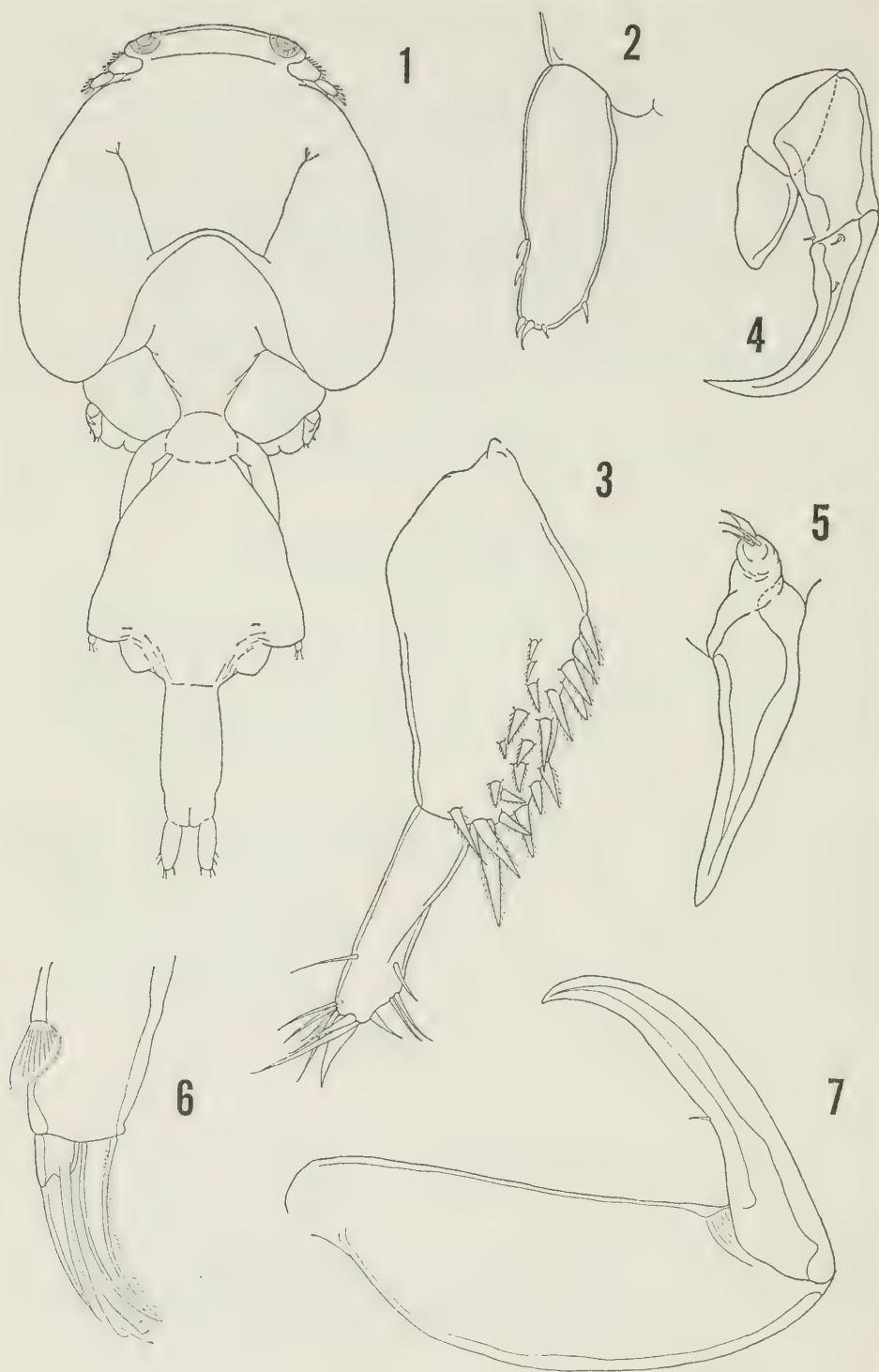
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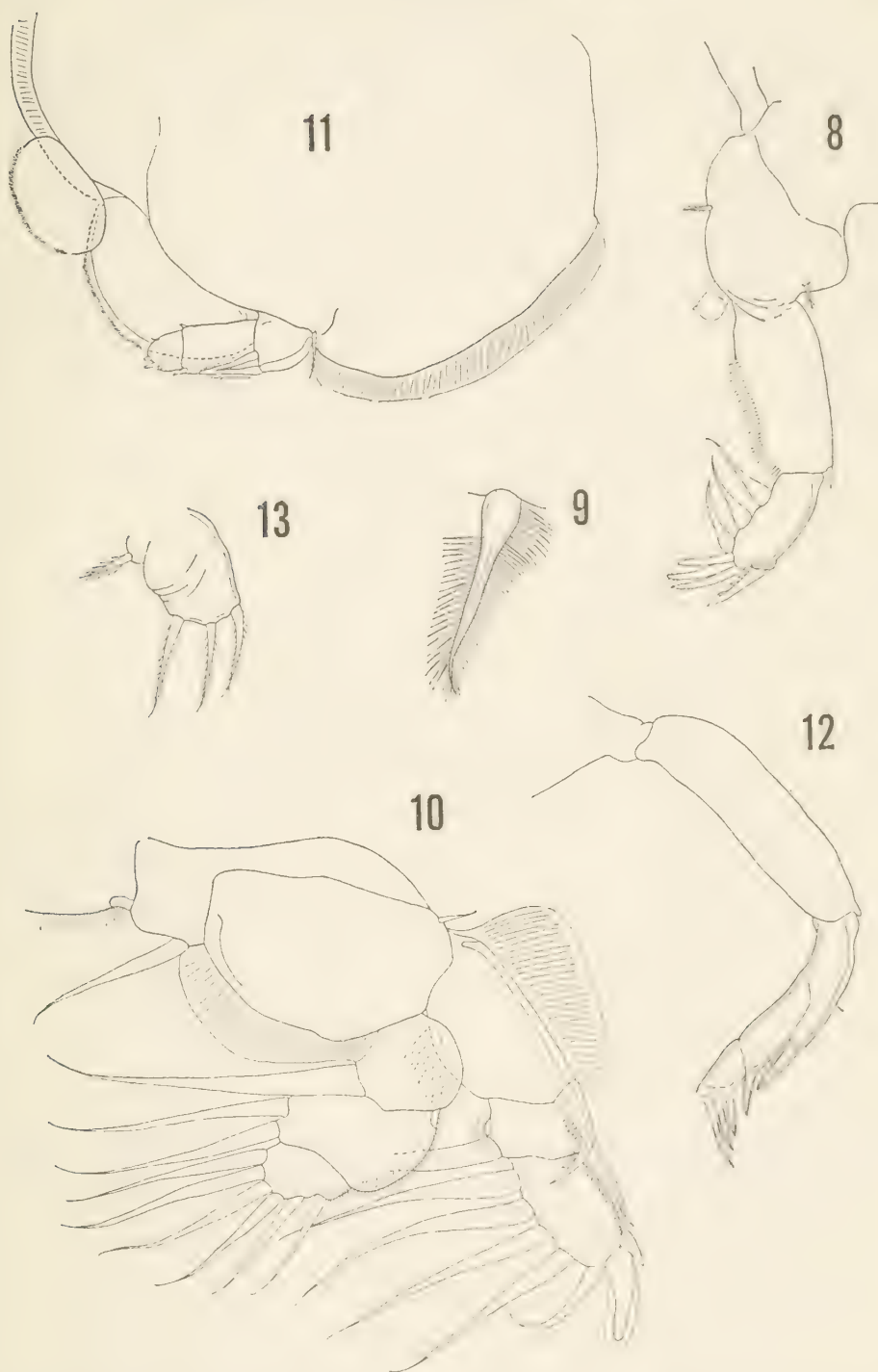
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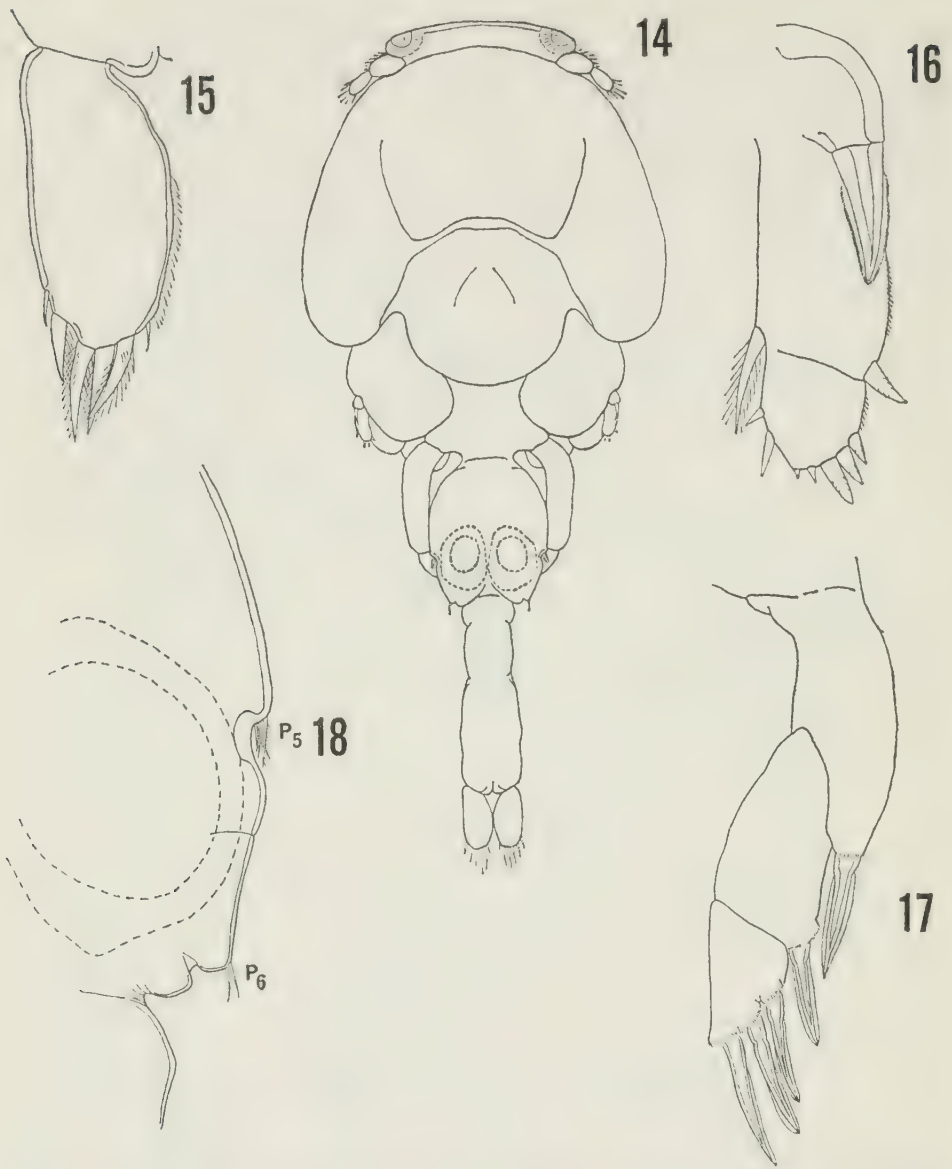
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FIGURES 1-7.—*Caritus serratus*, new genus, new species, female: 1, dorsal view; 2, caudal ramus; 3, first antenna; 4, second antenna; 5, first maxilla; 6, tip of second maxilla; 7, maxilliped.

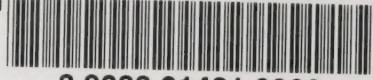


FIGURES 8-13.—*Caritus serratus*, new genus, new species, female: 8, leg 1; 9, inner seta on leg 1; 10, leg 2; 11, leg 3; 12, leg 4; 13, leg 5.



FIGURES 14-18.—*Caritus serratus*, new genus, new species, male: 14, dorsal view; 15, caudal ramus; 16, leg 3 exopod; 17, leg 4 exopod; 18, edge of genital segment.

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